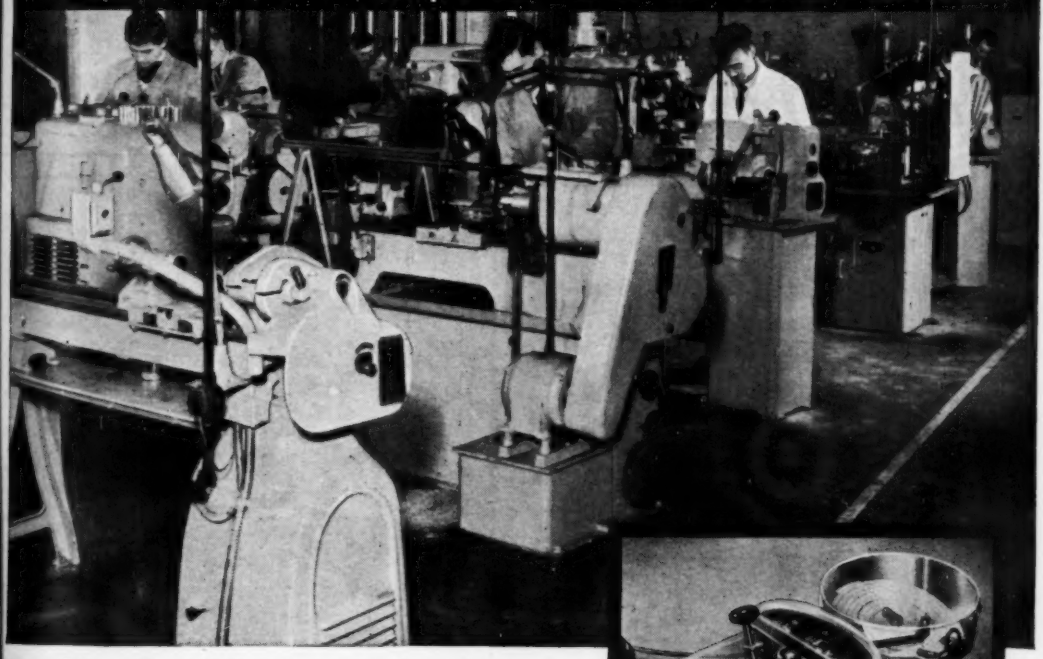
NATURE

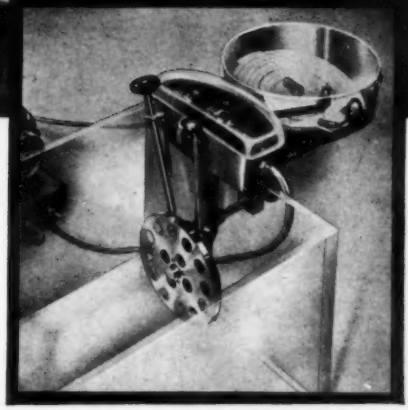
A Weekly Journal of Science

THE UNIVERSITY OF MICHIGAN
OCT 26 1960
UNDERGRADUATE LIBRARY

Vol. 188, No. 4745 SATURDAY, OCTOBER 8, 1960 2s. 6d.

This is the machine shop that makes the Techne Sentichart





The Sentichart records changes of 0·01°C in oil or water baths

TECAM

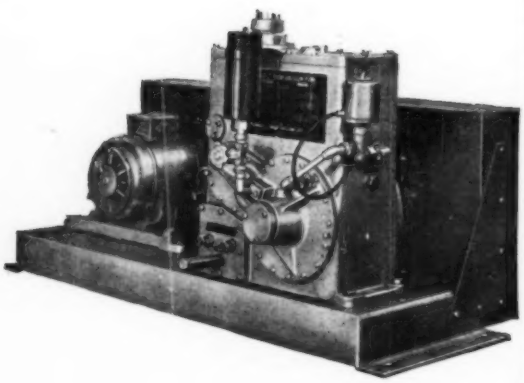
Operates within the range −75°C to + 175°C for 1 hr, 12 hrs or 72 hrs, over full chart scale of 0·35°C

TECHNE (CAMBRIDGE) LTD · DUXFORD · CAMBRIDGE · ENGLAND · Tel: Sawston 2246

"SPEEDIVAC"

best in the long run!

– and the quietest



Model	Stages	Ultimate Vacuum Torr*		Speed Litres	Standard A.C. Outfit Price
		Unballasted	Ballasted		
ISC30A	1	0·01	1·0	32	41 18 6
ISC50B	1	0·005	0·5	48	52 18 6
ISC150B	1	0·005	0·5	144	83 7 9
ISC450B	1	0·005	0·3	450	142 8 6**
ISC900	1	0·01	0·5	900	250 1 6**
ISC1500	1	0·01	0·5	1415	322 9 0**
ISC3000	1	0·01	0·5	2830	485 9 0**
2SC20A	2	0·001	0·05	22	48 6 0
2SC50B	2	0·0002	0·003	44	85 14 9
2SC150B	2	0·0001	0·0003	144	139 4 0
450/30	2	0·001	0·001	490	On Application†
900/50	2	0·001	0·001	980	On Application†
1500/50	2	0·001	0·001	1415	On Application†
3000/150	2	0·001	0·001	2830	On Application†

* Torr=mm Hg (BS.2951–1958)

** Supplied with 3 phase motor and starter

† Two-stage rotary pump combination, available with inter-stage condensers for use when pumping masses of vapour.

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY | SUSSEX | Crawley 1500

NATURE

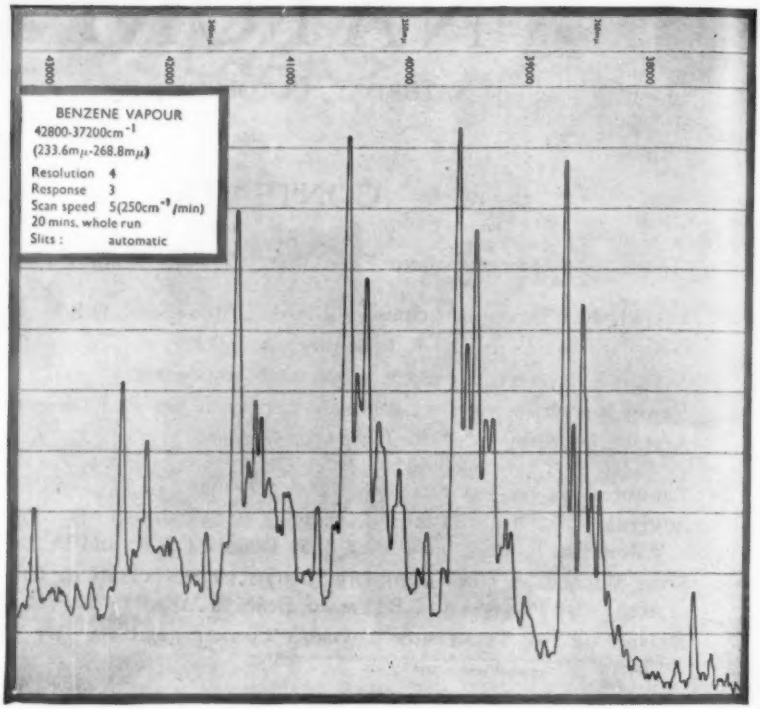
No. 4745 SATURDAY, OCTOBER 8, 1960 Vol. 188

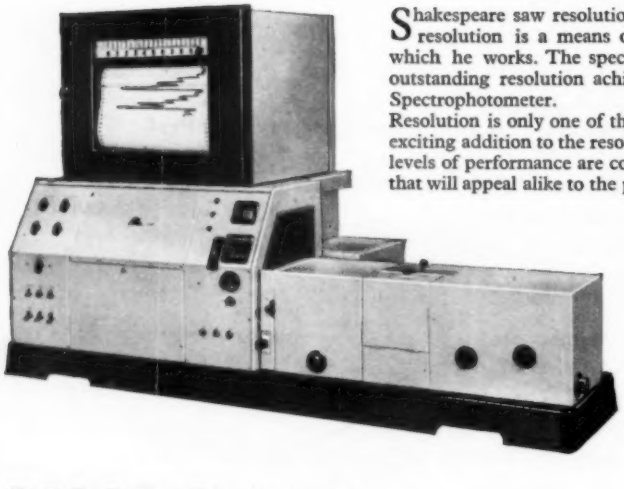
CONTENTS

	Page
Government Scientific and Technical Advisory Committees	85
Theoretical Hydrodynamics. By Prof. L. Rosenhead, O.B.E., F.R.S.	87
Logic and Science. By F. I. G. Rawlins, C.B.E.	87
A New Lunar Atlas. By Mrs. Simone Daro Gossner	88
New Approaches to Dynamical Astronomy. By P. J. Message	88
Applied Mathematics. By Prof. L. S. Goddard	89
Productivity of the Sea and Fresh Water	91
Scattering of High-Energy Electrons by Protons. By Prof. R. R. Wilson, Dr. K. Berkelman, Prof. J. M. Cassels, F.R.S., and Dr. D. N. Olson	94
Some Molecular Details of the Secondary Structure of Ribonucleic Acid. By Prof. Jacques R. Fresco, Bruce M. Alberts and Prof. Paul Doty	98
Report of the Television Advisory Committee, 1960. By Prof. Colin Cherry	101
Obituary: Prof. W. H. Lang, F.R.S. By Prof. John Walton	102
News and Views	103
Physics Education. By J. M. A. Lenihan	107
Seventh Congress of the International Soil Science Society. By Prof. N. R. Dhar	108
Soil Survey in the West Indies. By Prof. L. Dudley Stamp, C.B.E.	109
The Australian Atomic Energy Commission	110
Public Opinion Polls in Japan. By Edmund Leach	111
Mass Density near the Sun	111
Dwarf Mistletoes	112
Fact and Fiction on the Breeding of the Wandering Albatross. By Dr. R. Carrick, K. Keith and Dr. A. M. Gwynn	112
Chemistry of Visual Adaptation in the Rat. By John E. Dowling	114
Effect of Polyvinyl Alcohol on Chlorophyll and Hæm in *Chlorella* and *Tendipes*. By Bazyli Czeczuga, Dr. Leopold Rejniak and Dr. Henryk Fr. Nowak	118
Soil Movement by Denudational Processes on Slopes. By Dr. Anthony Young	120
Disorganization–Organization and the Reticular Formation. By Rodabé P. Bharucha-Reid	123
Concentration of Some Fission Product Nuclides in Ground-Level Air. By K. Edvarson and Kerstin Löw	125

(Continued overleaf)

"How high a pitch his resolution soars"





Shakespeare saw resolution as a virtue in man: to the spectroscopist, resolution is a means of evaluating the quality of the tools with which he works. The spectrum of benzene vapour above shows the outstanding resolution achieved by the UNICAM SP.700 Recording Spectrophotometer.

Resolution is only one of the features that make the SP.700 a new and exciting addition to the resources of the analytical chemist. The highest levels of performance are combined with a speed and ease in operation that will appeal alike to the precise research worker and the busy works chemist. Great savings in time and cost go hand in hand with a major increase in both quality and quantity of analytical information.

Write to-day for a copy of the new, comprehensive specification of the Unicam SP.700 Recording Spectrophotometer.

UNICAM *Ultraviolet, visible and near infrared*

SP.700 Recording Spectrophotometer

UNICAM INSTRUMENTS LIMITED · ARBURY WORKS · CAMBRIDGE

U195

LETTERS TO THE EDITORS

Page

PHYSICS

Magnetoresistive Measurements on Domain Rotation in Nickel–Iron Alloy Films.—Forrest G. West 129
Electrical Conductivity of Strontium Oxide.—M. J. Adams and L. Jacob 130
Soft Ultra-violet Photons in Self-quenching Geiger–Müller Counters.—Prof. Rafi Mohammed Chaudhri and Rahmat Ullah . . . 131
Impairment of Strength of Quartz Glass through Wetting by Liquids.—K. H. Hiller . . 132

RADIOPHYSICS

Effects of Vertical Diffusion of Electrons near the Magnetic Equator.—E. R. Schmerling . . 133

GEOPHYSICS

Stress-induced Magnetic Anistropy of Rocks.—F. D. Stacey 134

GEOLOGY

Charnockite in the Making.—Prof. C. S. Pichamuthu 135

CRYSTALLOGRAPHY

Super-Cell Structure of Semiconductors.—Dr. B. R. Pamplin 136

METALLURGY

Determination of Silver in Lead Concentrates by Atomic Absorption Spectroscopy.—B. S. Rawling, M. C. Greaves and M. D. Amos . . 137
Cathodic Cleaning of Metals before High-Temperature Oxidation.—Dr. D. Eurof Davies and S. N. Shah 138

CHEMISTRY

Phase Diagram of the System Vanadium Pentoxide–Boron Trioxide.—B. Nádor . . . 139
True Reactivity of the Organocadmium Compounds.—Dr. J. Kollonitsch 140
Detection of Iodine Compounds by Paper Chromatography.—José M. Calvo and Luz Bascur . 141
Gas Chromatography of Unesterified Fatty Acids using Polyester Columns treated with Phosphoric Acid.—Dr. L. D. Metcalfe . . . 142

BIOCHEMISTRY

Effect of Some Benzimidazoles on a Vitamin B_{12}-requiring Alga.—Dr. S. S. Epstein . . . 143
Enzymatic Transformation of Dehydroascorbic Acid to Diketogulonic Acid.—C. P. Tewari and Prof. P. S. Krishnan 144
Specific Protein of Legumes which reacts with Animal Proteins.—S. Nakamura, K. Tanaka and S. Murakawa 144
Inositol Phosphatide in Peas.—Dr. L. M. Lewin and Prof. A. C. Wagenknecht 146
5-Deoxycytidylic Acid-deaminating Activity in Human Gastric Mucosa and Other Adult Mammalian Tissues.—Dino Guerritore, Vincenzo Rocchi and Andrea Setzu . . . 146
Serotonin in Pineapple.—D. W. Bruce . . 147
Nitrite Oxidation by *Nitrobacter* in the Presence of Certain Nitrophenols.—Dr. W. D. Butt and Dr. H. Lees 147

PHYSIOLOGY

Inhibition of Appetite in Dairy Cattle by Certain Intermediate Metabolites.—Dr. Donald R. Dowden and Prof. Don R. Jacobson . . 148
Electrical Inexcitability of the Synaptic Membrane in the Frog Skeletal Muscle Fibre.—Prof. Robert Werman 149

Page

Absorption and Excretion of Copper in Mice.—Prof. David Gitlin, Walter L. Hughes and Charles A. Janeway 150
Growth of Mouse Femurs during Continual Centrifugation.—Prof. Charles C. Wunder, Stanley R. Briney, Melvin Kral and Charles Skaugstad . 151
Evidence of a Stimulating Action on the Central Nervous System by the Esters of Some Plant Growth Regulator Acids.—Dr. J. Thuillier, Germaine Thuillier and P. Rumpf . . 152

HÆMATOLOGY

Glutathione Stability Test in Hæmoglobin E–Thalassæmia Disease.—Sushiela Swarup, S. K. Ghosh and Prof. J. B. Chatterjea. . . . 153
Blood Groups of Selected Aboriginal and Indigenous Populations.—Prof. John Buettner-Janusch, Henry Gershowitz, Leopold J. Pospisil and Peter Wilson 153
Interrelations of Serum Protein Fractions in Normal Humans.—Dr. C. J. Brackenridge . 155

PATHOLOGY

A New Factor in the Use of Antibiotics.—Genoveva Tejerina and Antonio Portolés . 155
A Rapid Method of preparing Pure Serum Gamma-Globulin.—Dr. D. R. Stanworth . . . 156
Inhibition of Ehrlich Ascites Tumour Growth by Surface-active Agents.—Prof. M. E. Hodes, Aaron K. Warren and Dr. Catherine Gardella Palmer 157

ANATOMY

Intracellular Canals in Human Sweat Glands.—T. G. Scott 158
Lymph Node Reactivity to Homografts of Cancellous Bone.—Dr. R. G. Burwell and Dr. G. Gowland 159

BIOPHYSICS

Automatic Equipment for the Collection and Processing of Data from Geiger–Müller Counters.—Dr. Richard Scott 161
Identification of Ultracentrifugal Components in Human Plasminogen Preparations.—Prof. Sidney Shulman 161

BIOLOGY

Surface of a Parasite and the Hæmocytic Reaction of its Host.—Dr. George Salt, F.R.S. . . 162
Gestation Time for Delayed Birth in the Quokka.—J. W. Shield and Patricia Woolley . . 163
Electron Microscopy of Thysanuran Spermiogenesis.—R. S. Mathur 164
Influence of Amino Triazole on the Chloroplast Pigments of Wheat Seedlings.—Prof. Frederick T. Wolf 164
Complex Particles in *Hevea* Latex.—Dr. W. A. Southorn 165
A Comparison of Three Methods for the Assessment of Fungal Colonization of Seedling Roots of Leek and Broad Bean.—J. H. Clarke and Dr. D. Parkinson 166

ENTOMOLOGY

Number of Nymphal Instars of the Sugar-cane Froghopper.—Dr. D. W. Fewkes . . . 167
Decreasing Photoperiod inhibiting Metamorphosis in an Insect.—G. M. Blake 168

GENETICS

Evidence for a Gm^{ab} Allele in the Gm System of American Negroes.—Prof. Arthur G. Steinberg, Rachel Stauffer and Samuel H. Boyer . . 169
Chromosome Number in the Blue Fox (*Alopex lagopus* (L.)).—Dr. O. Lande 170

DIFCO *microbiological reagents and media*

Antisera and Antigens

Enteropathogenic Coli — Klebsiella

Salmonella — Shigella

Brucella — Leptospira — Streptococci

★

C Protein Antiserum and Standard

★

Infectious Mononucleosis Antigens and Standards

Over 60 years' experience assures UNIFORMITY · STABILITY · ECONOMY

Difco Laboratories

Prompt delivery from U.K. stock. Write for Difco Manual and technical leaflets to the sole agents:

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND

Branches in London, Manchester and Glasgow *Agents throughout U.K. and all over the world*

TAS/DO.5

Ultra-Violet & Infra-Red Sampling Instruments

ULTRA-VIOLET ABSORPTION CELLS
VARIABLE path-length cells for liquids
FIXED path-length cells for liquids

KBR EVACUABLE DIE
for making 13, 15 and 16 mm. Discs

INFRA-RED ABSORPTION CELLS
VARIABLE path-length cells for liquids
FIXED path-length demountable and sealed cells for liquids
MICROCELLS for liquids
GAS cells in pyrex and metal

HYDRAULIC 30-TON PRESS
especially designed for KBr Disc Technique

Rotating Electrode (Solution Excitation) Spark Unit

HIGH-SPEED VIBRATION MILL
indispensable for KBr Disc Technique
available for 230 volt 50-cycle and 110-volt 60-cycle mains

ROCK-SALT POLISHING KIT

RIIC Sampling Instruments are marketed by the leading spectrometer manufacturers of the world. Descriptive literature on application.

RESEARCH & INDUSTRIAL INSTRUMENTS CO.
116 Lordship Lane, London, S.E.22 Telephone: FOREST Hill 2281/2

GOVERNMENT SCIENTIFIC AND TECHNICAL ADVISORY COMMITTEES

IT is now some two years since the Prime Minister indicated in reply to a Parliamentary question that he proposed to inquire into the working of the present system of government in Britain from the point of view of easing the burden on Ministers and securing the more efficient working of Parliament. Although there have been several re-arrangements of Ministerial offices, including the appointment of a Minister for Science, no specific report or statement on the subject has yet been made to Parliament; though in reply to a Parliamentary question on November 30, 1958, it was stated that the Government is now advised by some 850 bodies of a central or national character. This is only one aspect of the problem, however, though it was discussed by Prof. K. C. Wheare in his book "Government by Committee" published in 1955, and received further attention in the wider survey by a study group of the Royal Institute of Public Administration entitled "The Organization of British Central Government 1914–1956" published in 1957.

Political and Economic Planning has now published a full-scale report on "Advisory Committees in British Government"*, based on a study made possible by a grant from the Leverhulme Trust. It is concerned solely with those advisory committees attached to departments of the central Government which are of a standing or permanent, rather than a temporary, character, and as local and regional committees are also excluded, it does not cover many of those included in the total given to Parliament in 1958. A table included in the report suggests that 484 is a more accurate figure for the purpose of this particular study, and a glance at this table should suffice to show how closely this aspect of government touches the scientist and technologist.

The assumption of new functions necessitated by broadening of the responsibilities of the Government mean that administration is no longer a self-contained system. A continuing need has developed for contact and consultation with people outside the Civil Service, and nowhere is this more important than in scientific and technical matters. This is one reason for the appointment of a Minister for Science, and the study of advisory committees is important, both for the light it throws on the means of developing effective contacts with professional groups and organized interests, and the provision of specialist and technical advice. Indeed, it is interesting to note that the Colonial Office, which appears to have led the way in setting up advisory committees of the modern type, had several such committees before the First World War, and they were all committees of experts and were concerned with scientific subjects, particularly with the development and use of scientific knowledge to improve the conditions of living in the territories with which they dealt. Such committees were appointed because the Colonial Office at that time lacked within itself scientific experts, and it emphasizes rather than otherwise the importance of the advisory committee in considering the place of the scientist in government and the means of presenting scientific and technical advice. The Haldane Report on the machinery of government in 1918, while making no recommendations regarding the organization of advisory bodies, foresaw an important place for such bodies and considered government administration was unlikely to retain public confidence unless "it was recognized as an obligation upon departments to avail themselves of the advice and assistance of advisory bodies so constituted as to make available the knowledge and experience of all sections of the community affected by the activities of the Department". Some two decades later, R. V. Vernon and N. S. Mansergh, in their study "Advisory Bodies", noted how the Haldane Committee's recommendation had reinforced the tendency to resort to external advice in this way, especially when the Government had to enter new spheres.

The survey prepared by Political and Economic Planning would be of great interest to the scientist and the technologist merely for the way in which it displays the extent to which scientific interests are affected by this tendency. It does not describe the operations of particular bodies, though the Advisory Council on Scientific Policy, the National Advisory Council on the Training and Supply of Teachers, the Colonial Research Council, the Engineering Advisory Council and the Advisory Council on Scientific Research and Technical Development of the Ministry of Aviation are among the fifteen major bodies the membership and functions of which are outlined in some detail by way of illustration, the last-named being of special interest in that no other account of its work appears to be available. More important, however, the survey reviews in succession just those aspects of the work of advisory bodies on which it is important that there should be public understanding not only in Parliament and among the specialist bodies whence the membership of such committees is often drawn but also in the country generally. Indeed, in the absence of such public understanding, the full advantages of such an advisory system are unlikely to be reached, because informed and intelligent discussion of public policy is hindered.

Beginning with a general review, in which the extent to which many committees are concerned with research, sometimes in an administrative rather than an advisory capacity, is duly stressed, and scientific committees as such receive a special note, Political and Economic Planning considers the problems of composition which may arise and their implications, the methods of work and the functions and influence

*Advisory Committees in British Government. Pp. xii+228. (London: Political and Economic Planning, and George Allen and Unwin, Ltd., 1960.) 25s. net.

of such committees. The difficulty of definition is frankly recognized, particularly that of differentiating between a committee responsible for advising on research programmes or policy, and one which is required to sponsor or organize research; but the research boards of the Department of Scientific and Industrial Research, the Medical Research Council, the Agricultural Research Council, the Nature Conservancy and the Overseas Research Council are regarded as possessing sufficient authority to be treated as administrative bodies, and as such are not discussed in the report, although the Scientific Advisory Council of the Ministry of Power is included. This limits to some extent the value of the survey as a discussion of the place of the scientific expert in administration, though here a major weakness is the failure of the report to make any reference to the need to have inside the Government, both at Ministerial level and in the Civil Service, those who are qualified to interpret and assess the scientific and technical advice presented to them.

This omission is the more striking in that, in the chapter on the functions and influence of committees, the nature of the problem is otherwise fairly stated, and the increasing reliance of a Government on advanced scientific knowledge, and hence on the specialists who are able to provide it, is fully admitted. Whether the need is met by employing scientific and professional staff inside the Civil Service, or by organizing the supply of knowledge from outside, there must be administrators and Ministers capable of assessing that advice in relation to other factors involved in matters of policy. This, of course, is largely a matter of education, but, while that point is overlooked, the report stresses the importance of education in the sense that it is effected by a sound public relations policy. The report takes a somewhat optimistic view of the influence of scientific committees, especially of the Advisory Council on Scientific Policy, and attributes the advantages of the advisory committee to its more systematic procedure, the more comprehensive personal contacts which it ensures, its general convenience and stability, and the more formal commitments it produces. The report questions seriously Prof. Wheare's suggestion that the development of advisory committees has strengthened Whitehall at the expense of Parliament; rather the view is held that the increased power of Ministers and their departments is counterbalanced by their dependence on independent organizations; and advisory committees are a feature of that dependence.

The report does not advocate unlimited publicity for the work of advisory committees; the risks of such publicity as well as those of excessive secrecy are both recognized. Indeed, this chapter of the report, with its clear discussion of the factors which assist or hinder the effectiveness of advisory bodies, deserves to be studied carefully both by the individual scientist and technologist and by his professional associations. One point in particular should be noted. The scientific community, the report comments, has not so far developed the unity and cohesion displayed by some trades and professions, nor do its political and social attitudes differ markedly from those of the rest of the populace. This may well explain the absence of professional associations of scientists or technologists from among the major nominating bodies listed as sending representatives or suggesting names for inclusion on the 484 advisory committees within the scope of the report. Even if the co-operation of scientists in the machinery of government does not become politically more important, this situation represents a serious weakness in some of the positions that may develop out of the present methods of recruitment of advisory committees.

The nature of that weakness is indicated by the title of a broadsheet "Government by Appointment" (No. 443, July 25, 1960), issued by Political and Economic Planning almost simultaneously with the report. This broadsheet reviews the practice and implications of the present system of appointments to a whole range of some 40,000 posts, from nationalized boards to regional and local bodies, many of which fall outside the scope of the report itself. Both the report and the broadsheet show that the need to secure people with particular qualities for particular jobs, and for Ministers to exercise some form of remote control over administrative bodies, has led to a new system of patronage which has come to stay, but appears to involve excessive plurality; this should be diminished if possible. The report only examines evidence of plurality from Home Office and Board of Trade committees, but there is no reason for regarding this evidence as atypical. Such plurality as exists is attributed mainly to the practice of nomination by outside organizations; and while it is not regarded as of serious proportions, it could with advantage be less.

The broadsheet suggests three principles that might guide policy in recruitment. The methods used should be, so far as possible, orderly and systematic, and should be widely known, so that nominations may come from all quarters. Within the limits imposed by the nature of the job, as great a variety of persons as possible should be appointed. Thirdly, plurality should be treated as a general problem and not considered merely in relation to a particular set of institutions. Until it has been fully examined on this basis, statements about the large numbers of people willing to give voluntary service should be treated with reserve.

Clearly, if this question of appointment to advisory committees is to be handled satisfactorily, so as to reduce plurality and establish public standards of propriety and good practice, professional associations of scientists and technologists have an important part to play. They might perhaps do more than at present to discover potential candidates among their membership, particularly in the younger age-groups, to arouse their interest in such work, possibly even to coach them or prepare them for participation. Moreover, there are other important matters to be discussed which bear alike on the effectiveness of advisory bodies and the willingness of professional men and women to serve on them; for example,

membership of any such committee may bring a scientist within the operation of the Official Secrets Act, with all its effects in his contacts and relations with professional colleagues outside the committee. Such issues are only just touched on in the report; but both report and broadsheet display a range of problems which touch the scientist and technologist closely indeed, and call for further study and independent thinking both by individuals and by their professional associations.

THEORETICAL HYDRODYNAMICS

Theoretical Hydrodynamics

By Prof. L. M. Milne-Thomson. Fourth edition. Pp. xxi+660+4 plates. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1960.) 65*s*. net.

THE book under review is the fourth edition of one which appeared for the first time in 1938. In the pages of *Nature* (**142**, 1136; 1938) I discussed a number of text-books on hydrodynamics before dealing specially with the first edition of Prof. Milne-Thomson's book. In that review I ventured to suggest that the mathematical approach to hydrodynamics followed in the book might well have been amplified by a more physical approach. That is still my view, but I must add that Prof. Milne-Thomson's book has had a resounding success during the twenty-two years that have elapsed since it first appeared. I have come across many experts, both in Britain and abroad, who have spoken very highly of "Theoretical Hydrodynamics" and of the approach adopted in the book. To that extent I misjudged the need for a comprehensive book of the kind planned and written by Prof. Milne-Thomson. Each successive edition has been amplified to some extent and has incorporated new material.

There is no unique road to the study of hydrodynamics. There is the approach of the physicist who treats the subject as a branch of physics in which there are discussed the forces which act on liquids, and which are exerted by them. There is also the approach of the engineer, who is concerned mainly with applications, though some of the modern applications of hydrodynamics to engineering are compelling experts to try to obtain a deeper insight into fundamental processes than appears to have been necessary in the past. Then there is the 'express route' to trans-sonic, supersonic and hypersonic flow, which appears to be much favoured nowadays, avoiding the gaps in our existing knowledge of subsonic hydrodynamics. Prof. Milne-Thomson has taken none of these paths—his is the road of the mathematician. Clear physical statements are transformed into mathematical assumptions, and the mathematics of hydrodynamics is developed with clarity and economy. The practical and theoretical sides of the subject are made to supplement each other, but the emphasis remains that of the mathematician. The virtue of this method is that as "a scientific theory becomes more exact, so does it of necessity tend to assume a more mathematical form", and Prof. Milne-Thomson's approach seems to have found considerable support. In 1938 his method, which is based consistently on vector methods and notation, was considered to be a departure from the traditional approach, but it is now generally accepted and is followed by many applied mathematicians.

Chapter 1 of the book is concerned mainly with inferences which may be drawn from the 'pressure theorem' of Daniel Bernoulli, who may justly be considered to be the father of hydrodynamics—the word 'hydrodynamica' was first used by him about 1780. Chapter 2 discusses those properties of vectors which are essential for the analysis of the motion of a fluid element and for the formulation of the equations of hydrodynamics. In Chapter 3 there are discussions of the general basic properties and equations of fluid motion. Chapter 4 is concerned with the mathematical properties of two-dimensional motion in so far as they can be treated without the complex variable. Chapter 5 introduces the complex variable, and conformal mappings are treated in some detail.

Chapters 6–14 treat two-dimensional motion from the unified point of view of the complex variable. In Chapter 6 there is a discussion of streaming motion followed, in Chapter 7, by a consideration of Joukowski aerofoils, while sources and sinks are dealt with in Chapter 8. In Chapter 9 the motion of a moving cylinder is treated in detail and Chapter 10 discusses specialized aspects of conformal mapping and their applications. Chapters 11 and 12 contain important applications to the discontinuous motion of jets, currents and cavities. Chapter 13 concerns itself with the motion of vortices, and the drag associated with a vortex wake. Chapter 14 deals with two-dimensional wave motion.

In Chapter 15 the Stokes stream function is introduced, and the general motion of spheres and ellipsoids is treated in Chapter 16. In Chapter 17 Milne-Thomson derives Kirchhoff's equations in vector form. Chapter 18 discusses vortex motion in general, with special application to aerofoils of finite span. Chapter 19 gives an outline of the application of vector methods to viscous fluids and a brief description of boundary layer theory. Chapter 20, the final chapter of the fourth edition, is designed as an introduction to the theory of flow of a compressible fluid at subsonic and supersonic speeds.

The presence of well-graded sets of exercises at the end of each chapter is much appreciated by many of those who teach hydrodynamics to mathematicians in British universities. The appearance of the book is clear and attractive, and the text is lavishly illustrated with line drawings and photographs which have been chosen with discretion.

Prof. Milne-Thomson's book has stood the test of time and has, in fact, been accorded increased recognition with each successive edition. Within the limitations which Prof. Milne-Thomson set himself, and which are clearly stated in the preface, his book on theoretical hydrodynamics may be described as being 'of the first water'. L. ROSENHEAD

LOGIC AND SCIENCE

An Introduction to the Logic of the Sciences

By R. Harré. Pp. viii+180. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1960.) 21*s*. net.

THIS is a very welcome book. It should be said at the outset that the author's intention to write largely for undergraduates in science may prove a little on the modest side, since many students working for higher degrees would probably produce

substantially better theses if they could find time to read what Dr. Harré has to relate.

Part 1 deals with scientific discourse, and Part 2 with discovery and confirmation. Translated into working terms, this means a discussion on the place and understanding of 'models', followed by a thorough drilling in the reasons why laws and theories come to be accepted or rejected as the case may be. In the latter context, the author adopts a sound *via media* in his warning against premature jettisoning of a theory which may, indeed, be inadequate, but perhaps for instrumental reasons. Returning to the role of models in theoretical physics, the dangers of taking them too literally are partly due to giving excessive weight to what scientists say, rather than to what they do. In the light of history, the Rutherford–Bohr planetary atom served its generation well, and signified effectively what happened in the Cavendish Laboratory; but nobody could seriously have thought that the particular imagery would last. Yet, the grand point is that—from the aspect of discovery—disciplined insight came first, and the application of mathematical analysis afterwards. Essential as the latter is, momentous advances usually begin with remarkably simple premises. Incidentally, Max Planck is known to have fought hard and long in his mind against the consequences of his own quantum concept. The statistical and indiscriminate nature of much of modern physics was not to his liking. But that is the penalty of greatness. Questions like these are ably handled by Dr. Harré, and the moral is driven home.

Towards the end of the volume, some finer points of procedure are illustrated in the chapters dealing with "fitting the facts", and "non-factual criteria". In the first of these, the development of van der Waals' equation out of Boyle's law is treated epistemologically. It is highly important in showing the student that if he performs his experiment $pv = constant$ properly he ought to find discrepancies, and that these are due to his working with *real* gases.

The other matter is quasi-æsthetic, namely, the place of 'elegant' proofs in science. It is suggested that the inclusion of some ingenious device is needed for satisfaction of this kind. Maybe it is; but the most sublime thought can be 'symmetrical' and 'well-rounded' rather than 'angular', and this may have something to do with it. In the greatest minds, these qualities are undoubtedly revealed, and, fascinating as the subject is, we may well have to leave it at that.

F. I. G. Rawlins

A NEW LUNAR ATLAS

Moon Maps, with a Chart showing the Other Side of the Moon based upon Soviet Photographs
By H. P. Wilkins. Pp. 36+27 maps. (London: Faber and Faber, Ltd., 1960.) 30*s*. net.

When H. P. Wilkins died, on January 21, 1960, the astronomical world lost one of its most dedicated selenographers. His last undertaking was the preparation of a lunar atlas designed for use at the telescope. These new "Moon Maps" are based on an earlier set published in his volume "The Moon" (in collaboration with Patrick Moore, 1955), which is undoubtedly familiar to amateur lunar observers.

The accompanying text is limited to a gazetteer in which all named features, indexed alphabetically, are described briefly and keyed to the corresponding maps. The latter are reproduced on a scale of 55·4 miles to the inch and are therefore approximately 40 per cent larger than those in the 1955 volume. The entire visible surface of the Moon is covered in 25 sections. In addition, the area surrounding the walled plain of Ptolemaeus is shown on a larger scale, and a map of the far side has been prepared from the photographs obtained in October 1959 by means of *Lunik* III.

The most unusual feature of the atlas stems from its very imaginative binding. Whereas the pages of text are spiral-bound in the conventional way, the maps are attached to the outer edge of the back cover, thus allowing the reader to place side by side any page of the gazetteer and any chosen map.

It is unfortunate that the author's failing health evidently prevented him from giving the book a final critical review before it went to press; but the few obvious omissions are by no means irreparable. In particular, the enlarged map of Ptolemaeus (Plate XXVI) bears no title and the word Ptolemaeus itself does not appear anywhere on the page; since Plate XXVI is not indexed in the gazetteer and is mentioned only briefly (by the anglicized name Ptolemy) in the introduction, this very useful map is apt to be overlooked by the casual reader.

The key chart, which appears on p. 47 of "The Moon", is absent here and would be a welcome addition, especially because the co-ordinates of the new maps are printed in type so small as to be nearly illegible in the dim light of a telescope dome. The names of the features are rather inconspicuous, too. This is of course necessary for preserving the many fine details which otherwise would have been obliterated; but these formations could be located more easily if approximate co-ordinates had been included in the gazetteer.

In spite of these few shortcomings, "Moon Maps" should be nevertheless a valuable addition to the reference shelf of the amateur observer for its abundance of minute details not readily available elsewhere.

Simone Daro Gossner

NEW APPROACHES TO DYNAMICAL ASTRONOMY

Introduction to the Mechanics of the Solar System
By Rudolf Kurth. Pp. ix+177. (London and New York: Pergamon Press, 1959.) 42*s*. net.

The study of the dynamics of the solar system, which until a few years ago appeared to be almost in abeyance, has recently shown signs of a renewal of interest. This was in large measure initiated by the development of high-speed automatic computers, vastly accelerating the large amounts of numerical calculation intrinsically associated with the subject, and has been augmented by the launching of artificial satellites and space probes, which have brought new problems in dynamical astronomy with them. As a consequence there is a need for introductory books to the subject, one or two of which have appeared in the past few years, and it is into this category that this book falls.

The general approach of the book is empirical, and its simple and direct treatment (making use of vector notation throughout), as well as the inclusion of elementary explanatory material in the first chapter,

will make it of great value to those making their first acquaintance with the subject, even if they have little or no previous knowledge of the composition of the solar system, the planetary motions, or even of Newton's laws of motion and of gravitation. The first chapter shows how Kepler's laws of planetary motion may be arrived at inductively from the observations, and discusses the solution of Kepler's equation, with some analytical results. The second chapter examines the notion of force, laying down postulates for it, deriving the inverse square law, and obtaining the general solution to the general two-body problem. This chapter also contains a brief but clear description of the bases of Laplace's and Gauss's methods of orbit determination. Chapter 3 is concerned with the many-body problem, in several of its aspects. In Section 4 there is an unusual and instructive derivation of the time derivatives of the orbital elements in terms of the components of the disturbing force, based on Poisson's method of variation of parameters. (The fact that the expression for the acceleration is analytic in the time does not resolve the question of the convergence of the first-order perturbations, as suggested in Section 2·2, since the relevant radius of convergence may be very small, and in fact some modern work suggests that it is so.) Chapter 4 deals with the oblateness problem in broad principle, and Section 2 gives a lucid treatment of the precession and nutation, using vector and matrix notation, and deriving the major terms. At the end of each chapter there is a set of instructive examples for solution of varying difficulty, and some useful notes and references.

The study of orbital perturbations has given rise, in the past two centuries, to a vast edifice of mathematical developments and techniques (including the distinction of various classes of term in the expansion of the disturbing function, and the wide use of canonical transformations), and the author, in his wish to view the subject more directly from the point of view of the physical principles involved, betrays his impatience with some of these developments. This attitude is capable of leading to important new insights, and is not too much out of place in an introductory work; but it is a pity that the author expresses such especially violent lack of confidence in the Hamilton-Jacobi method (both in the Introduction and in the notes to Chapter 3), especially since he does not reach those problems where the method exhibits its power, as, for example, those related to the long-period features of orbital perturbations, or to the special conditions arising near small integer commensurabilities of period, or near the critical inclination in the artificial satellite problem.

P. J. Message

APPLIED MATHEMATICS

Mathematics in Physics and Engineering

By J. Irving and N. Mullineux. (Pure and Applied Physics: a Series of Monographs and Textbooks, Vol. 6). Pp. xvii+883. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 11.50 dollars.

THIS book presents a comprehensive account of those parts of mathematics which find application in the solution of problems in physics and engineering. The tone of the book is practical and 'down to earth', with emphasis on solutions carried to the numerical stage. It will be valued by the applied mathematician, at least as a reference book, because so much material is covered in its almost 900 pages of text. Each chapter is accompanied by a set of problems (with answers) and the text is copiously illustrated with problems worked out in detail. Thus the book is admirably suited to the needs of students, but it is not likely to help the research mathematician very much, since it is not a specialized text and the reference lists are not very extensive.

The first chapter deals with methods for solving partial differential equations, and includes a section on Cauchy's problem and the solution of hyperbolic, elliptic and parabolic equations. Chapter 2 is devoted to the solution of ordinary differential equations and it introduces a number of the special functions. On the other hand Bessel and Legendre functions receive amplified treatment in Chapter 3. Laplace and other transforms are introduced in Chapter 4, and some applications to problems of oscillation are discussed. Chapter 5 deals with matrix algebra, with emphasis on numerical work, such as solving equations or finding latent roots. Analytical methods in classical and wave mechanics are presented in Chapter 6, and these are illustrated by reference to the top and the linear harmonic oscillator.

Chapter 7 treats the calculus of variations. It covers the usual elementary problems and also isoperimetric problems and the Rayleigh-Ritz method. Some torsion and viscous-flow problems and some elastic plate problems are solved. There is a section on the binding energy of the helium-4 nucleus; but about twice the experimental value is obtained from a theoretical calculation, and then it is remarked that this shows that "the assumed interaction is not valid". It seems to me that it would have been better to omit this section, or, if the aim was to give an application of the variational calculus to theoretical physics, then an example where the result is more in accord with experiment might have been chosen.

Complex variable theory, the calculus of residues, and conformal transformations find widespread applications in physics and engineering; they are adequately covered in Chapters 8 and 9, which together occupy about 150 pages. General transform theory is dealt with in Chapter 10, and application is made to various problems of supersonic flow. Chapter 11 is on numerical methods, and Chapter 12 deals with integral equations, both analytical and numerical methods of solution being presented. The numerical treatment of integral equations deserves special mention. It goes further than that given in any other book known to me. There is an appendix of 80 pages on various topics in pure mathematics; it will mainly be of use for reference purposes.

The work should be of great assistance to senior undergraduates, and to physicists and engineers who move in the world of technology. If it is a matter of deciding, in a practical case, whether mathematics can help, this book will go a long way towards answering the question. So far as the actual printing is concerned, this is very clear. But the mathematical formulæ and equations are frequently displayed in such a way that space is not utilized very efficiently, such as on p. 527 or 579. Formulæ and prose might have been combined in some places, and in others the formulæ printed on several consecutive lines might have all been put on one line. In spite of this, however, it must be admitted that the Academic Press has produced the book at a reasonable price.

L. S. Goddard

Annual Review of Physiology

Vol. 22. Edited by Victor E. Hall, in association with Frederick A. Fuhrman and Arthur C. Giese. Pp. viii+725. (Palo Alto, Calif.: Annual Reviews, Inc., 1960.) 7 dollars.

THE "Annual Review of Physiology" has appeared regularly since 1939. The new number is much like its predecessors: it provides a fairly complete, but not very critical, summary of the year's literature. There is an interesting prefatory chapter by Dr. Franklin D. McLean, who has seen great changes in physiology since he took his degree in 1910—the year when Abraham Flexner's report on medical education appeared. He has come in close contact with many famous men—A. J. Carlson, L. J. Henderson, Otto Loewi, A. E. Cohn, Baird Hastings and many others, and has done much to make medicine scientific.

The new volume contains a cumulative index of chapter titles for Volumes 11–22. Articles on the adrenal cortex, heart, peripheral circulation, digestive system, kidney, reproduction, respiration, and three or four articles on the nervous system appear each year. This year there are articles on the comparative physiology of muscle and blood pigments and there are articles on nuclear function, genetics, the alimentary tract, vision, and the thyroid. There are no more reviews of Russian physiology.

The preface directs especial attention to the article on the regulation of volume of the blood by E. B. Reeve, T. H. Allen and J. E. Roberts of Colorado. In this article, quantities such as the rate of uptake of water from the gut, the rate of flow to and from the interstitial space, and the intracellular space are defined algebraically in terms of various symbols. The relations between these quantities are then expressed as formulæ. The precise definitions given facilitate the discussion of the experimental papers reviewed, and will help to clarify thought in a complex field. This is a new departure for annual reviews; it is a constructive article and will provoke thought and criticism. It is hoped that more such reviews will appear in later volumes. J. H. Gaddum

Ancient Mexico

An Introduction to the Pre-Hispanic Cultures. By Frederick A. Peterson. Pp. 313+24 plates. (London: George Allen and Unwin, Ltd., 1959.) 35*s*. net.

AN up-to-date account of Mexican archæology is badly needed, and this book goes some way towards meeting that need. The author clearly knows his material, and he has had the advantage of long residence in Mexico, but these very qualifications may be responsible for his writing in some places in a way which will be understood better by the specialist than by the general public to which the book is directed. Rather a serious drawback is the way in which its general arrangement and tone obscure the differences between the Classic and Post-Classic Periods, particularly the introduction of large-scale war and violence with the arrival of the Toltecs at the beginning of the Post-Classic.

There are a number of points of detail which could be criticized; however, most of these will affect the general reader but little. Two only will be noted here because they will increase the natural difficulty which that reader may be expected to find in grasping the essentials of the Maya calendar and numerical system. One is a statement that "all the day names come 5 days later in the following year"; what is meant is that the day name in the 260-day cycle of the first day of a 365-day year falls 5 days later in that list of names than that of the first day of the preceding 365-day year, so the result is that a given day name will be shifted backwards by 5 days, not forwards. The other is a misprint of 2259 against a Maya number 2258.

The publication of this book raised hopes that it might take the place of Vaillant's "Aztecs of Mexico" which is out-of-date in some respects though still very valuable in others. Although it is quite a useful work, by comparison with Vaillant's it is a dull production. G. H. S. Bushnell

Paper-Making Practice

By H. Hardman and E. J. Cole. Pp. xi+334. (Manchester: Manchester University Press, 1960.) 45*s*. net.

THOSE best qualified to write books on this subject seldom have the time or incentive to do so. This work was begun when the authors were lecturing at the Manchester College of Technology, and they have relied almost completely on the scientific literature and on machinery manufacturers' publications. It is therefore greatly to their credit that they have managed to assemble a remarkable amount of useful practical information, set out in simple language.

The book is a modified version of a series of articles which appeared in a trade journal, and it presupposes a fairly considerable knowledge of pulp and paper manufacture. Unfortunately, it is marred by some serious defects. Thus, the treatment of the subject is extremely un-even (wood pulping receives 74 pages, but rag and esparto pulping, of principal interest in Britain, are omitted); it is not particularly up to date (for example, in respect of methods of stock preparation, continuous pulping, fines removal, wire and felt construction); and of the approximately 110 literature references only two are subsequent to 1955. There are no index, no link-up between the body of the book and the bibliography, and no references to text-books (not even to "Clapperton"); and the text itself sorely needs editing.

Nevertheless, the book can profitably be read by the students and paper makers to whom it is addressed, and I hope that it will soon reach a second edition, when the above defects can be remedied and its value thereby greatly enhanced. J. Grant

Biographical Memoirs of the National Academy of Sciences of the United States of America

Vol. 34. Pp. vii+368+15 plates. (New York: Columbia University Press; London: Oxford University Press, 1960. Published for the National Academy of Sciences of the United States of America.) 40*s*. net.

WITH the exception of those of J. U. Nef (1915), L. V. Pirsson (1919) and L. B. Stillwell (1941) all the subjects of these memoirs died within the last decade, and most within the last three years. The memoirs are characterized by the high standard which has come to be associated with this series, and they will be valued also for the comprehensive bibliography which accompanies each memoir. Apart from those names already mentioned, those best known to British scientists are probably W. E. Bachman, R. A. Daly, C. F. Kettering, M. S. Kharasch, O. Meyerhof and W. R. Whitney.

PRODUCTIVITY OF THE SEA AND FRESH WATER

IT was appropriate that Section D (Zoology) of the British Association meeting at Cardiff should devote a session to the "Productivity of the Sea and Fresh Water" when the subject of feeding humanity loomed large in the deliberations of the Association as a whole. Indeed it was all the more timely for, as Dr. C. E. Lucas pointed out in the course of the session, one could see no mention at all of the sea or its potential in the programme of the Association's whole-day general symposium on "World Food and Population Problems".

The session was opened by Sir Alister Hardy, who outlined the natural economy of the sea by way of introduction and then, after stressing the need for getting more food from the sea, proceeded to discuss various ways in which the yield might possibly be increased. Apart from the development of new fisheries, better conservation of stocks already fished and other such fishery problems which would be dealt with by Dr. Lucas, he sought to answer the question: "Can we come any nearer to actually farming the seas?".

The manuring or the fertilizing of the waters with phosphates and other chemicals which had been so successful in confined freshwater fish culture could scarcely be used in the sea, he thought, except in certain very limited areas. The late Dr. F. Gross and his colleagues during the Second World War had demonstrated that such chemicals could be so used, but only in the land-locked arms of a sea loch; the open sea itself is too big a place to be treated in such a way on any large scale.

Sir Alister then referred to recent experiments conducted by Mr. J. E. Shelbourne, of the Fishery Laboratory at Lowestoft, in the rearing of young plaice in large nursery tanks until they were past the delicate stage at which the greatest mortality occurs in the sea. A number of sea-fish hatcheries, he said, have been established in the past, but it has been very doubtful if they really contributed much to the increase in the stocks of fish because the fry were liberated at far too early a stage; now, through Mr. Shelbourne finding how to keep them successfully until much later in their development, there is a new and real hope of adding materially to the fish stocks by such means.

He then recalled the experiments of the late Prof. Walter Garstang in the transplantation of young two-year-old plaice from the over-crowded coastal banks of Holland to the Dogger Bank, where they were shown to grow so much more quickly. Prof. Garstang had worked out the cost of transplanting millions of such young fish in ships specially fitted with tanks for the purpose, and had shown that such enterprise could yield a handsome profit to the industry; such farming, however, has not yet been possible because no one nation would put in the capital when all others would be free to reap the benefit. The time, however, will come, Sir Alister believes, when the need to get more food from the sea will bring about closer international co-operation in such matters.

Sir Alister ended his contribution by discussing another possible way of farming the sea which, while admitting that it lay very much in the future, he believed would be most important and should be prepared for. His ideas for such farming, he said, arose from considering the researches of Dr. Gunnar Thorson, the distinguished Danish marine biologist, who has shown that there is a much heavier competition on the sea-bed, from various animals such as starfish, for the food available for fish, than was originally thought. In a recent paper Dr. Thorson has demonstrated that such invertebrate predators will actually eat about four times as much food as will a quantity of fish of the same total weight; this, Thorson says, leads to "the amazing fact that only 1 to 2 per cent of the (potential) fish food is actually eaten by the fish".

These findings present a great challenge to marine biologists. Will future farmers of the sea be able to eradicate some of these pests and so step up the quantity of fish which may be carried on a given area? asked Sir Alister Hardy, and he went on to express his belief that this will eventually come about. If Dr. Thorson's calculations are correct, and if we could eliminate just a quarter of the pests and so allow the fish to have some 20, instead of just 2, per cent of the potential food supply, then we could make an area support ten times the quantity of fish that it does to-day. How could they be eliminated? Just as we harrow and roll the land in addition to reaping our crops, Sir Alister believes that we will in time systematically drag some combing or other devices over the sea floor at intervals to weed out the creatures that take the food from the much more valuable fish; and the pests themselves may well be converted into poultry food. Looking to the still more distant future, he believes that the fishermen of a hundred years hence may be frogmen working tractor-driven trawls sent down from parent ships above and pulling starfish eradicators over the sea bed. But whatever the future holds, he stressed, any such farming of the sea will require much more pure ecological research to determine just which of the animals we can do with in smaller numbers.

The second speaker was Dr. C. E. Lucas, director of Scottish Fisheries Research. The sea, he reminded us, is still our major highway, the very active natural boundary of all our lands, and an almost incalculable natural source of power. As the envelope of a sea-bed covering 70 per cent of the Earth's surface, it must be as rich in minerals as the land, or even richer. In addition, it is the source of our valuable marine fisheries.

With rare exceptions, the problem of the fishermen in taking their catch is a very difficult one; both they and the scientists have to work in the dark. Just before the Second World War, science began to help with the adaptation of the echo-sounder for 'seeing' fish as well as the sea bed, and since then scientists have used it with the under-water camera and television; but the fisherman still needs all the aid he can get. What are we doing about it? Dr. Lucas

asked. The answer, he said, depends on how we view the problem. On one hand, the knowledge we already have of the seas and their resources is a tribute to the skill of the fishermen and the scientific progress already made. From another aspect, with the vastness of the oceans and their potential value in view, both the harvest and the scientific effort are small.

Except during the Wars, over the past fifty years, Britain has taken each year about a million tons of fish from the north-east Atlantic: its present value at first sale is about £50 million. During that time the European catch increased steadily, and it stood at some eight million tons in 1957, when the Food and Agriculture Organization estimated the world's marine catch at nearly 30 million tons, compared with 20 million in 1938. These figures are themselves impressive enough until we compare them with those for agriculture: for the world, around 1,000 million tons of vegetable produce and probably 50–100 million tons of animal protein. So, despite its size, the sea's present yield is not so impressive after all, and it is chiefly this fact that has limited our research and exploratory investment. There is, however, another way of looking at this marine harvest; in terms of the yield per fisherman, it can compare very favourably at times with the agricultural yield per man. Why is it, then, that we get so little from the seas compared with the land?

There are, of course, many reasons, among which the problem of distributing the catch to populations far from the sea is important; it is being slowly conquered by research designed both to improve the means of preserving and transporting fish over greater periods and distances, and to provide forms of fish-meal which shall be attractive for direct human consumption. Primarily, however, it is because we are still very old-fashioned and unscientific in our exploitation of the seas. This is neither a criticism of research work nor of the hard-working fishermen. The fisheries scientists must necessarily direct a large proportion of their effort to the problems of the industry as it exists, while the fishermen can only afford to fish for profitable markets. It is simply a statement of fact, for there are many more fish, and other animals, in the sea than ever came out.

The conventional fish stocks are based on the continental shelf. The fish fluctuate in abundance, largely in response to variations in the ocean currents and the plankton which 'supports' them and the animals of the sea-bed. But their abundance also depends on man himself, with his frequently wasteful fishing; success has usually led to ruthless exploitation until the stock has been unable to recruit and grow as fast as man has reaped. In slowly reproducing animals such as whales, this has led to near extinction; but fortunately most fish stocks are more resilient and respond rapidly to a reduction in fishing.

These matters are among the objects of study in marine laboratories and particularly fisheries laboratories. Here Dr. Lucas went on to review some of the important lines of fisheries research carried out at these laboratories; but as he said, viewed in relation to agricultural and industrial research, the whole is pathetically small. Yet it has given a general picture of the sea and its riches which demands further investigation and exploitation.

The seas occupy more than 70 per cent of the world's surface and have their own natural crop of plants and animals. While these vary considerably from place to place, we now know that their overall productivity, in terms of plant matter, is at least as great as that of the land, about 100,000 million tons (+) per annum. One of our problems at present is to know just how productive it is, and the final answer may be that, acre for acre, it beats the land. Here, however, comes one of the big differences. On the land, most of the basic production is in terms of grass, trees and other plants which are often directly usable. With the exception of the seaweeds, on which a not unimportant industry is now developing, production in the sea is based on countless myriads of unicellular plants, from which vast crops might be taken, except that they are individually so small that we do not know how to harvest them. At present we have to rely on the fish and whales to harvest them for us, mainly via the small animals which feed directly on the plants, and with them form the plankton. Only in a few instances do we know much of the food-chains in the sea; but we do know that there is a great loss in productive efficiency at each stage, that is, between the plants and the animals that feed on them, between these animals and the next larger ones, etc.—perhaps 80–90 per cent in each step. So that the original 100,000 million tons (+) of plant matter produced is probably reduced to about 1–2,000 million tons (+) in terms of animals of a size conventionally acceptable for food. Yet that is far greater than the 30 million tons caught at present. Not all these sizeable animals are fish, of course, but a large fraction of them are; of the others, many are molluscs or crustaceans such as have long been familiar to us as food, and many more are representatives of animal groups which already provide food in one part of the world or another.

Considered from this position, can we—either Britain or the world as a whole—afford to view the seas merely as a source of 30 or even 50 million tons of fish? Even in food terms alone, it is a potential source of protein too valuable to be taken in the present somewhat primitive way. But the oceans have other significance for us. Can we afford any longer to treat marine research as almost the Cinderella of the sciences? Does it not deserve a place among the major groups of investigation basic and applied? asked Dr. Lucas. He then discussed in more detail the further potential food supplies we can anticipate from the sea. He dealt with increases to be expected, on one hand through a better and international conversion of stocks already fished, and on the other through the exploitation of new stocks as yet untapped. He also considered new fisheries for smaller species of fish, at least for conversion to fish-meal, if not for direct human food; and this could free for man's consumption fish such as the herring which are being unnecessarily taxed for such uneconomic purposes as animal feeding. Then, after considering further some of the possible farming methods discussed by Sir Alister Hardy, he turned to the possible harvesting of plankton.

There are, Dr. Lucas said, the distant but enormous possibilities of the natural plankton itself. Even now the larger zooplankton is caught and eaten in some parts of the world where circumstances are particularly favourable. In general, however, we have not yet the means to harvest either the phytoplankton or the zooplankton; but, in the richer areas, such as the polar regions, the annual production presents a challenge which may some day be accepted. At present we can merely set against the difficulties and

the costs, and the fact that whales and fish harvest these for us freely, the loss we incur by taking less than 0·1 per cent of the total marine production. To acquire that fraction the world uses more than a million vessels of various sizes and probably more than 4,000,000 men. Some day, when the incentive is great enough, as for many 'miracles' it was during the War, some of us will see that in true perspective, and decide that such an effort deserves a greater return and therefore a major effort to see whether a solution cannot be found.

The sea, then, at present gives us some 30 million tons of animal protein, etc., and we can have every confidence in that being at least doubled by the simple application of present knowledge and techniques, and probably more cheaply in human effort than now.

Finally, Dr. Lucas said that in Britain, we are now spending about £1¼ million a year on marine research of all kinds, compared with about £7 million on agricultural research, to say nothing of medicine, defence and atomic energy. We are also talking of spending millions more on space research, and the Americans and Russians are thinking in terms of hundreds of millions a year. Yet there are vast unexplored spaces off our coasts which are intellectually and physically as exciting as any; we know less of the sea-bed than we do of the face of the Moon.

The two contributions on freshwater fisheries to the symposium which followed were concerned with tropical conditions and were more specialized. Dr. R. S. A. Beauchamp, until recently director of the Jinja Laboratory on Lake Victoria, dealt with the lake fisheries of East Africa. The abundant light and heat of the tropics, he said, provide ample energy, so that, other things being equal, tropical lakes should be more fertile and more productive than those in temperate regions. The abundance of fish and other animals (hippopotami, crocodiles, etc.) found when some of the East African lakes were first visited had seemed to provide proof of this, yet their exploitation has shown that they are not as productive as they seemed to be; research has given at least a partial explanation.

For a number of years the stocks provided all the fish required. With the increase in the human population, however, the demand for fish increased and the fishery was greatly developed; in consequence, in Lake Victoria the fish were reduced to about one fiftieth of what they were. This has not caused the alarm it should, because the gross annual yield has been maintained by increasing the fishing effort. The methods for investigating the productivity of these lakes are the same as those used for temperate ones; but only after a time does one realize how very different a tropical lake is. In a temperate-zone lake, the vital processes go on at a rate determined by the weather and the changing seasons; in the tropics these are constant or vary only slightly. This, he said, puts the question of what determines the rate of productivity in rather a new light, and it becomes apparent that in a tropical lake this is determined by its own characteristics; there are certain physical circumstances which limit production in any given lake, but within such limits it is determined by the biological processes themselves.

With this idea in mind, one is forced to consider what these lakes were like before they were heavily exploited: when they contained, according to the earliest records, very many more fish than they do now. These records have by some been discredited or considered as exaggerated. However, there are, in East and Central Africa, still a few lakes that have not been heavily exploited or have only been opened up recently, and all these provide evidence for the validity of the records regarding the number of fish originally found in lakes such as Lake Victoria.

It is generally recognized that any natural complex of plants and animals, if left to itself, will develop so as to produce and support the maximum number of living organisms. It is also fairly apparent that, almost without exception, man's interference in any such natural biological resource leads to its deterioration. The African lakes vividly illustrate these two contentions. Man has caused so much damage because he strikes at the most crucial link in the succession—where plant material is being converted into animal material. This conversion is brought about, not, as in other lakes, by the invertebrate animals, but directly by fish belonging to the genus *Tilapia*, which feed on phytoplankton.

With an excess of light and heat, a limit to plant growth is set by the rate at which nutrients become available. In Lake Victoria (and probably some other lakes) a primary deficiency has been shown to be a shortage of sulphate; and it was also found that the inflows contained little or none of this. However, the main supply of nutrients in a large lake is not from its inflows but from its bottom deposits. In Lake Victoria the organic content of the bottom muds was found to be extremely high, containing enormous quantities of organically combined sulphur. Here in contact with the water we have an abundance of the very substance that constitutes a deficiency. How this comes about is not yet fully explained, but the mud contains organisms which seem to prevent the usual processes of decomposition and decay; thus the nutrients in the plankton that falls to the bottom are largely removed from circulation. For this reason, it is very desirable that as much as possible of the plankton should be eaten in order to keep up the general level of fertility by the return of animal excretion; to this end considerable stocks of *Tilapia* should be maintained in the Lake. Unfortunately, these fishes form the basis of the commercial fisheries and suffer the severest exploitation. Twenty-five years ago an officer of the Sleeping Sickness Department who had spent most of his life on Lake Victoria said he thought it was becoming a watery desert; this is even more true to-day.

The concluding speaker was Dr. C. F. Hickling, fishery adviser to the Colonial Office, who described experiments on the effects of fertilizers on the fish yield at the new Fish Culture Research Station in Malacca. It is well known, he said, that the natural production of fish in a pond can be greatly increased by the use of fertilizers and the supply of supplementary foods. But fertilizers are cheap, both in cost and labour, whereas foods are by comparison expensive and tending to be more so. Therefore fish-pond economy demands that the maximum increase in fish production should be got by the use of fertilizers, with supplementary feeding as an extra.

Temperatures at Malacca are high and show little variation (27° C. at night; 32° C. by day), so growth is very rapid. Since earlier work suggested that a neutral or slightly alkaline reaction is essential for the successful use of fertilizers, the first series of trials tested the effects of graduated doses of calcium

carbonate, given as powdered limestone, on the water and the fish stocked in the ponds. All the experiments were done in 36 one-acre ponds arranged as a Latin square (6 × 6) and each stocked with 250 common carp and 200 *Tilapia mossambica*; after six months the ponds were drained and the fish crop weighed. It was shown that the yield of fish was not increased even though acidity was neutralized and alkalinity increased four-fold.

Next the same ponds were used to test the effect of 20 lb. of phosphate (P_2O_5), given as triple superphosphate, on the fish production at three different levels of limestone dosage, and also the effect of potash (K_2O) with and without phosphate, against an untreated control. The potash without phosphate gave no significant increase in yield over that of the control or of the former experiment; the phosphate, however, gave an important effect in every case: even in the unlimed ponds, it increased the fish crop from 93 to 217 lb., and in the limestone ponds it was increased to 344 lb. In a third series of experiments it was shown that the addition of nitrogen (as calcium nitrate) gave no significant increase over phosphate alone, and it also showed that the addition of 20 lb. of phosphate gave as good a crop of fish as nearly 7 tons of cowdung. 40 lb. of phosphate gave the highest yield of all—an average of 373 lb. with a maximum of 551 lb. In summing up, Dr. Hickling said the lessons to be learnt from these experiments are, first the paramount importance of phosphates, and secondly the rapid rate of turnover, which is to a large extent a function of temperature; this latter factor, he believes, accounts for the far better utilization of phosphates shown at Malacca as compared with earlier German experiments in colder temperate waters.

Both the marine and freshwater contributions gave rise to a good general discussion.

SCATTERING OF HIGH-ENERGY ELECTRONS BY PROTONS

By Prof. R. R. WILSON, Dr. K. BERKELMAN, Prof. J. M. CASSELS*, F.R.S., and Dr. D. N. OLSON

Laboratory of Nuclear Studies, Cornell University, Ithaca, N.Y.

THE elastic scattering of electrons by protons is described[1] by the Rosenbluth formula (lengths will be expressed in fermis, and $\hbar = c = 1$. For momenta $1 f^{-1} = 197$ MeV./c.):

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{4E^2}\,\frac{\cos^2\theta/2}{\sin^4\theta/2}\left[1 + \left(\frac{2E}{M}\right)\sin^2\theta/2\right]^{-1}$$

$$\left\{F_1^2 + \frac{q^2}{4M^2}\left[2(F_1 + \varkappa F_2)^2\tan^2\frac{\theta}{2} + \varkappa^2 F_2^2\right]\right\} \qquad (1)$$

where $\frac{d\sigma}{d\Omega}$ is the laboratory differential cross-section, α is the fine structure constant, E is the laboratory energy of the incident electron, θ is the laboratory angle of scattering, M is the proton mass, $q^2 = 4E^2\sin^2\theta/2[1 + (2E/M)\sin^2\theta/2]^{-1}$ is the square of the four-momentum transfer, and $\varkappa = 1{\cdot}79$ is the anomalous magnetic moment of the proton in nuclear magnetons. The form factors F_1 and F_2 are associated respectively with the Dirac and Pauli interactions of the proton with an electromagnetic field.

The formula, of course, relies on the validity of conventional quantum electrodynamics, and also on the absence of fourth-order processes in which two photons are exchanged between the electron and the physical nucleon. Both assumptions are expected to be valid in the conditions of the experiment described here, although the second one may well break down at energies not much greater[2].

For convenience a cross-section $\frac{d\sigma'}{d\Omega'}$, loosely referred to as the 'point proton cross-section', may be defined by writing $F_1 = F_2 = 1$ in the formula; then experimental results can be expressed in terms of $F^2(q^2,\theta)$, where:

$$\frac{d\sigma}{d\Omega} = F^2(q^2,\theta)\,\frac{d\sigma'}{d\Omega} \qquad (2)$$

Clearly F can be expressed in terms of F_1 and F_2 as required.

Hofstadter *et al.*[3], using electrons with energies up to 650 MeV. from the Stanford linac, have studied the scattering at 75° ($q^2 \lesssim 11 f^{-2}$) and 135° ($q^2 \lesssim 17 f^{-2}$). Their results are well fitted by writing:

$$F = F_1 = F_2 = (1 + 0{\cdot}0533\,q^2)^{-2} \qquad (3)$$

A recent letter by Hand[4], who also used the Stanford linac, reports measurements at 135° for $q^2 \approx 26 f^{-2}$. These results are also consistent with equation (3).

This article reports an investigation of the scattering in which q^2 ranged up to $25 f^{-2}$ at 66° and at 112°. As will be seen, the results at the higher angle agree with Hand's. At the lower angle, on the other hand, a variation of F^2 with θ is revealed which can only mean that F_1 and F_2 are not equal.

Apparatus and Procedure

Figs. 1 and 2 show vertical and horizontal views of the general layout and of the counter telescope. The electron beam of the Cornell synchrotron spiralled inwards at the peak of the magnetic cycle,

* Now at the Chadwick Laboratory, University of Liverpool.

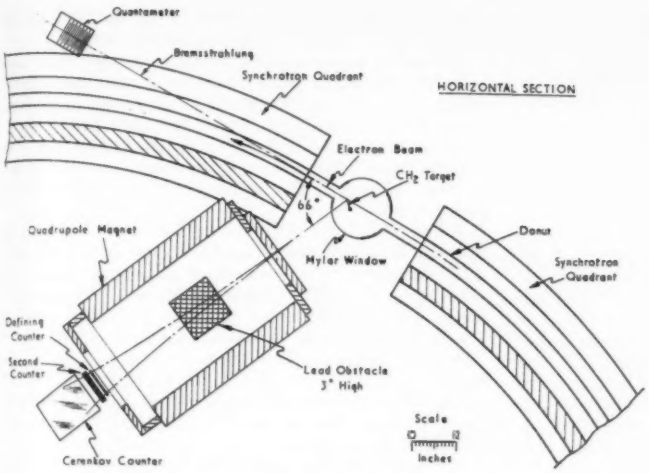


Fig. 1. Plan view of the apparatus described in the text

as a result of controlled decrease of the radiofrequency accelerating voltage. For periods of about 1 msec., repeated 30 times per sec., the electrons bombarded polyethylene or carbon targets in a scattering chamber located in one of the straight sections. The targets were in the form of rods about 1/16 in. square, disposed horizontally in the median plane of the synchrotron at an angle of 45° to the beam direction. The tips of the targets were 1·1 cm. inside the normal equilibrium orbit of the beam. Discoloration of the polyethylene showed that the targets were bombarded at distances up to 1/16 in. back from the tips.

A totally absorbing ion chamber, or quantameter[5], integrated absolutely the bremsstrahlung emitted from the target. Knowledge of the radiation-length of the target materials at the various electron energies gives directly the effective product of the target thickness and the incident electron charge, which is the quantity required for cross-section calculations. It was evident that on the average the electrons traversed the target about ten times before being finally lost from the synchrotron.

Photographs were taken of the bremsstrahlung spot immediately in front of the ion chamber. Usually these showed a clean spot about 1/4 in. in diameter, which checked that electrons were not hitting objects, other than the targets, in or near the scattering chamber. In the early stages of the experiment a second diffuse spot was sometimes caused by electrons hitting a beam-detecting device at the upstream entrance to the chamber; this improper mode of operation was associated with incorrect monitoring and low measured cross-sections. The trouble was eliminated by adjustment of the in-phase correction coils which steer the synchrotron beam at high energies.

Scattered electrons, or recoil protons, left the scattering chamber through a 0·005-in. 'Mylar' window and were then deflected magnetically by a single quadrupole lens. This produced vertical focusing of the particles passing over or under a central obstacle 3·7 in. high, made of lead and copper. The momentum window of the spectrometer was defined by this obstacle and by the plastic scintillator A, the maximum height of which was 1/8 in. In vertical section this scintillator had the shape of a truncated diamond, in order to obtain the best possible bias curve for the pulses.

The quadrupole lens was, of course, defocusing horizontally, and therefore scintillator A was made 8 in. wide. In a typical run the collected particles were emitted at semi-horizontal angles up to 0·97°, measured at the target with respect to the central ray; the total solid angle collected by the spectrometer was 4·41 millisteradians.

The momenta of the particles varied with the horizontal angle of emission, an effect which was only appreciable for recoil protons. To compensate for it, scintillator A was turned through a small angle (for example, 18° at 1,205 MeV.) round its vertical axis, counterclockwise as seen from above.

For a point target on the axis the theoretical curve of detection efficiency versus magnetic field gradient, for a fixed momentum particle, was trapezoidal in shape. It had an almost flat top and a typical full width of 3·1 per cent at half-efficiency. In practice the resolution curve was smeared by the finite height of the target and various multiple scattering processes, especially for recoil protons. However, the area under the peak should not be seriously changed by these effects, and so the cross-sections were computed by integrating peaks in the experimental counting-rate as a function of magnetic field gradient. Actually the voltage across a shunt in series with the exciting coils of the magnet was used as the independent variable, and the areas multiplied by an appropriate constant. At the highest momenta the field gradients were not quite proportional to the existing currents,

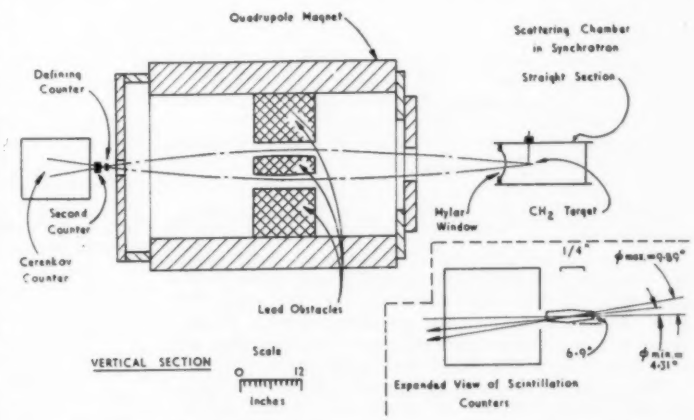


Fig. 2. Side view of the target, spectrometer, and counter telescope. The inset shows an enlarged view of the two scintillation counters

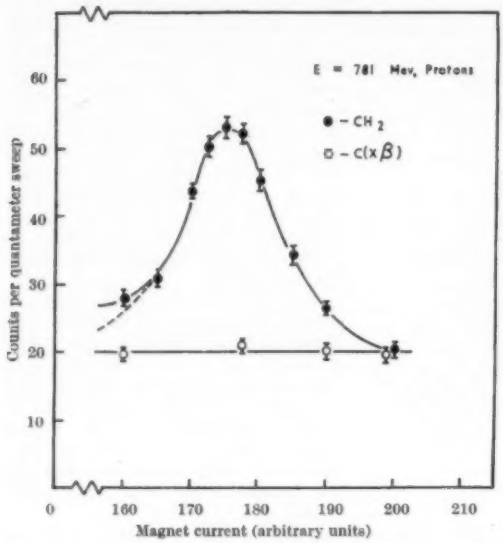


Fig. 3. The counting-rate as a function of magnet current; protons recoiling at 66° from collisions of 781-MeV. incident electrons

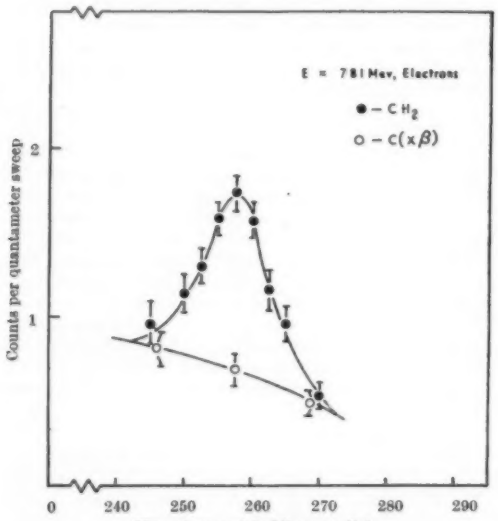


Fig. 4. The counting-rate as a function of magnet current; electrons scattered at 66° from collisions of 781-MeV. incident electrons

and a differential correction ($\gtrsim$ 9 per cent) was made for this.

The procedure just outlined was used for (*a*) the 66° scattering of 587, 684, 781, 879 and 1,034 MeV. electrons, (*b*) the 112° scattering of 320 and 761 MeV. electrons, and (*c*) the protons recoiling at 66° from the scattering of electrons with energies of 684, 781, 982, 1,034, 1,173 and 1,205 MeV.

The counting rate was measured only in the region of the peak for (*d*) the 66° scattering of 982, 1,085, 1,173, and 1,215 MeV. electrons, and (*e*) the 112° scattering of 909 MeV. electrons. The corresponding cross-sections were evaluated using the line shape established in the full sets of measurements.

The other two counters in the telescope were used to reduce backgrounds. Counter *C* was inoperative when the comparatively slow recoil protons were being detected, and the bias on the plastic scintillator counter *B* was raised so that relativistic particles were not detected. Coincidences between counters *A* and *B* were required, the effective pulse widths being about 0·5 μsec.

When electrons were being detected the bias on counter *B* was lowered, and counter *C* was brought into operation. This was a lead glass total absorption Čerenkov detector, which produced recognizably large pulses when the desired electrons arrived. Triple coincidences between counters *A*, *B* and *C* were required, the effective width of the mixed pulses being about 20 ns. for *A*, 200 ns. for *C*, and 0·7 μs. for *B*. Each triple coincidence event opened an electronic gate, allowing the output from counter *C* to reach a pulse-height analyser.

At all times the electronic equipment was gated by a 4 ms. pulse locked to the peak of the magnetic cycle of the synchrotron. This reduced corrections for cosmic ray events ($\lesssim$ 10 per cent, but usually negligible).

Results

Figs. 3 and 4 show respectively the recoil proton and the scattered electron peaks observed at 66° from 781-MeV. incident electrons. The ordinates are the coincidence counts observed per 'sweep' of the quantameter (1 sweep = $4{\cdot}97 \times 10^{12}$ MeV.), and the abscissæ are the voltages in the spectrometer shunt.

The counting-rate as a function of the magnet current after subtraction of the rate from carbon

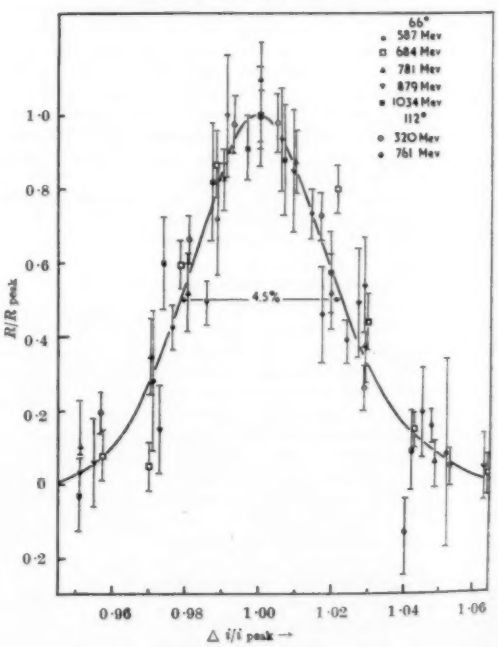


Fig. 5. Line shape of the peaks caused by elastically scattered electrons

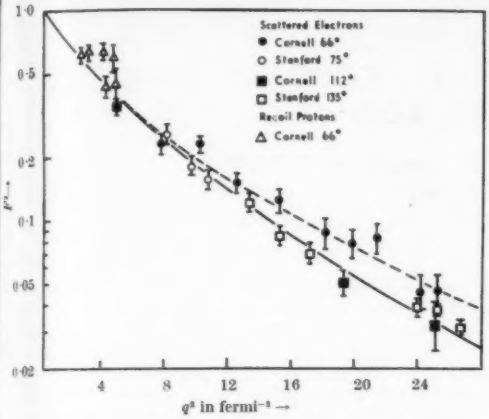


Fig. 6. Experimental results, including Stanford results at high q^2. The full line is given by the formula $F^2 = (1+0{\cdot}0533\ q^2)^{-4}$, while the dashed line is fitted to the 66° experimental points at high q^2

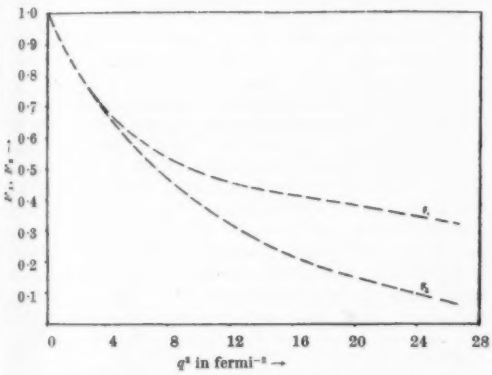


Fig. 7. The individual form factors required to reproduce the full line of Fig. 6 at 135°, and the dashed line of Fig. 6 at 66°

The carbon target results have been multiplied by a normalizing factor $\beta = 0{\cdot}89$, which equalizes the effects of the carbon nuclei in the two target materials. Rather clean elastic peaks are revealed in both figures, although there is a small inelastic tail in the proton distribution. Fig. 5 shows the line shapes observed in all the complete sets of electron measurements, before correction for saturation.

It was found that the height of a peak decreased slowly if a given polyethylene target was bombarded for a long time. Presumably this was due to ejection of the hydrogen from the target, an effect probably correlated with a brownish discoloration which also appeared. The polyethylene targets were changed every few hours and a suitable correction for ageing was established and applied ($\lesssim 3$ per cent).

Finally, the usual radiation correction ($\lesssim 13$ per cent) was applied to allow for the emission of bremsstrahlung in the electron-proton scattering process.

The results, expressed as a plot of F^2 against q^2, are shown in Fig. 6. For comparison some of the results of Hofstadter *et al.* are also shown, together with those of Hand.

Discussion

The results of the present experiment clearly agree well with the Stanford data wherever they overlap, that is for $q^2 \lesssim 11\ f^{-2}$ when $\theta < 90°$, and for $q^2 \lesssim 26\ f^{-2}$ when $\theta > 90°$. Often the form factors at low q^2 are expanded in the static approximation:

$$F_{1,2} = 1 - \frac{1}{6}\, a_{1,2}^2\, q^2 + \ \ldots \qquad (4)$$

where $a_{1,2}$ are the root mean square radii of the charge and the anomalous magnetic moment of the proton. Thus no change is indicated in the conclusion of Hofstadter *et al.* that these radii are about $0{\cdot}8\ f$. It should be noted, however, that equation (4) is subject to relativistic and dynamic corrections of the order of q^2/M^2, so that the exact physical significance of this line of interpretation is not very clear.

At high values of q^2 the points for $\theta < 90°$ (circles and dashed line in Fig. 6) flatten out[6] and lie consistently higher than the points for $\theta > 90°$ (squares and full line in Fig. 6). This behaviour indicates that F_1 and F_2 are not equal, and in fact an average of the points near $q^2 = 20$ gives $\frac{F_2}{F_1} = 0{\cdot}37\ ^{+\,0{\cdot}17}_{-\,0{\cdot}14}$. Fig. 7 shows the individual values of F_1 and F_2 which would give the dashed and full lines of Fig. 6 at angles of 66° and 135° respectively. The two form factors must behave in this general fashion, although at present their values have clearly not been determined with precision. (This conclusion was reported by one of us (R. R. W.) to the Tenth Annual Rochester Conference on High Energy Physics (August 25–September 1, 1960). A subsequent paper by Prof. R. Hofstadter included a similar deduction on the basis of recent work at Stanford.)

The flattening out of F_1 at $q^2 \approx 12\ f^{-2}$ must be associated with the inner structure of the proton, at radii of the order of $0{\cdot}3\ f$. The charge density in this region may be expected to include contributions from virtual states containing nucleon–antinucleon pairs, kaons and multiple pions. It is likely to be some time before these various effects are disentangled with any certainty.

The most promising line of theoretical attack is based on the dispersion theory[7,8] of the isotopic scalar and vector parts of the nucleon form factors. Unfortunately there are no general theorems relating the neutron and proton form factors, so that data on electron–neutron scattering at high q^2, for both large and small angles, are needed before further progress can be made.

We are indebted to Dr. P. C. Stein and Mr. D. Edwards for help in taking readings, and to Mr. A. Contogouris for helpful discussions on theoretical matters. Mr. P. D. O'Neill gave valuable help with numerical computations. The co-operation of the synchrotron crew is gratefully acknowledged.

This work was supported by the Office of Naval Research and the U.S. Atomic Energy Commission.

[1] Rosenbluth, M. N., *Phys. Rev.*, **79**, 615 (1950).
[2] Drell, S. D., and Fubini, S., *Phys. Rev.*, **113**, 741 (1959).
[3] Hofstadter, R., Bumiller, F., and Yearian, M. R., *Rev. Mod. Phys.*, **30**, 482 (1958).
[4] Hand, L. N., *Phys. Rev. Letters*, **5**, 168 (1960).
[5] Wilson, R. R., *Nuclear Instr.*, **1**, 101 (1957).
[6] Berkelman, K., Cassels, J. M., and Wilson, R. R., *Bull. Amer. Phys. Soc.*, II, **5**, 282 (1960).
[7] Chew, G. F., Karplus, R., Gasiorowicz, S., and Zachariasen, F., *Phys. Rev.*, **110**, 265 (1958).
[8] Federbush, P., Goldberger, M. L., and Treiman, S. B., *Phys. Rev.*, **112**, 642 (1958).

SOME MOLECULAR DETAILS OF THE SECONDARY STRUCTURE OF RIBONUCLEIC ACID

By Prof. JACQUES R. FRESCO*, BRUCE M. ALBERTS and Prof. PAUL DOTY

Department of Chemistry, Harvard University, Cambridge, Mass.

THE Watson-Crick structure for deoxyribonucleic acid[1] and the Pauling-Corey structure for the α-helix in proteins[2] represent unique chain conformations that permit maximum hydrogen bonding and impose rigidity on the otherwise flexible chains. The several highly specific functions of ribonucleic acid suggest that it also must have a unique spatial arrangement that only a periodic chain conformation, that is, a secondary structure, can provide.

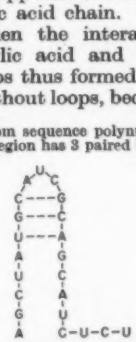
Nearly two years ago, it was shown that a number of physical chemical observations on ribonucleic acid were consistent with its having a partial (40–60 per cent) helical structure in dilute neutral saline at low temperature[3,4], and these conclusions have since received further support[5–8]. At that time it was proposed that each chain consists of a number of imperfect hairpin-like helices similar in character to those of deoxyribonucleic acid, united by flexible, unstructured regions. However, the proposal lacked definition on two important points: it was not clear how half the bases in ribonucleic acid could fit into helical regions; and in connexion with this, it was not known how large a helical region had to be in order to satisfy the observed thermal stability. The object of this communication is to show how recent experimental studies on synthetic polynucleotide analogues remove these difficulties and permit a more specific delineation of the secondary structure of ribonucleic acid.

Nature of the Base Pairs: It is now possible to propose with some confidence that the helical regions of ribonucleic acid are similar to those in deoxyribonucleic acid, that is, they contain the adenine-uracil and guanine-cytosine hydrogen-bonded base pairs. Of the many base pairs which have been examined in helical polynucleotide structures, these have been found to interact most strongly[3,9,10]. Furthermore, they appear to be the only pairs which are mutually conformable in a regular helical framework. Consequently, the structure common to the adenine-uracil and guanine-cytosine pairs can be expected to be favoured, and since in this framework all other base pairs are either sterically intolerable or are separated by too large a distance to form hydrogen bonds, their existence is regarded as unlikely. Consistent with this view, a linear correlation has now been demonstrated between the thermal stability of a variety of ribonucleic acids and their guanine-cytosine contents (Fresco, J. R., and Givelber, H., unpublished observations).

Accommodation of Successive Base Pairs: The consequence of adopting a deoxyribonucleic acid-like structure for the helical regions of ribonucleic acid is that severe sequence requirements would appear to be necessary in order to realize the 40–60 per cent level observed in ribosomal[3,4], tobacco mosaic virus[3,4] and transfer ribonucleic acid[11]. For example, a *random* sequence of the four bases can readily be shown to allow only about 20 per cent helical development even if two adjacent base pairs are accepted as 'helical regions' (see Fig. 1*a*). However, when it was found that a synthetic copolymer containing a random arrangement of adenylic, guanylic, cytidylic and uridylic nucleotides displays about the same helical content as ribonucleic acid[3,4], the notion that sequence restrictions make possible the high helical content had to be rejected.

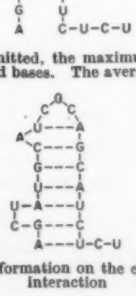
An attractive solution to this dilemma has come from a recent study of helix formation between homopolymers and copolymers of adenylic and uridylic acids which revealed an additional degree of freedom in polynucleotide conformations[12]. In this work it became evident that when chains of poly-uridylic acid were mixed with chains of a copolymer of adenylic acid and uridylic acids (with adenylic acid the dominant component), the optimal base-pairing occurred when the number of uridylic acid residues in poly-uridylic acid equalled the number of adenylic acid residues in the poly-adenylic-uridylic acid chain. From this it was concluded that all the uridylic acid residues in the copolymer were looping out from the helical structure, so that only adenylic acid residues remained opposite the uridylic acid residues of the poly-uridylic acid chain. Comparable results were obtained when the interacting species were poly-uridylic-adenylic acid and poly-adenylic acid. The helix-with-loops thus formed is weaker than the equivalent helix without loops, because the presence of

For a particular random sequence polynucleotide of 22 residues the maximum helical region has 3 paired bases. The average is 2



(*a*)

When loops are permitted, the maximum helical region has 7 paired bases. The average is 6



(*b*)

Fig. 1. Effect of loop formation on the efficiency of base-pair interaction

* Established Investigator of the American Heart Association, Present address: Department of Chemistry, Princeton University, Princeton, New Jersey.

loops brings about a concentration of negative charges and therefore increases electrostatic repulsive forces, and because the accommodation of the loops probably introduces some strain in the adjacent helical regions. Consequently, loops conspire with the shortness of the helical regions to lower the T_m value (where T_m is the temperature at the mid-point of the helix-coil transition) which is a measure of helix stability. In the case of poly-uridylic-adenylic acid and poly-uridylic acid, helical complexes were stable at 25° C. only if they contained less than about one-third of their residues in looped form. In these complexes all the loops occur only in the poly-uridylic-adenylic acid chain.

In ribonucleic acid the helical regions are shorter and the loops probably exist in both strands of these regions. These factors would tend to lower the fraction of residues that could be permitted in a helical region. However, the presence of the much stronger guanine-cytosine bonds[10] would probably more than compensate for this effect. For example, a helix having equal numbers of adenine-uracil pairs ($T_m = 61°$) (refs. 3, 4) and guanine-cytosine pairs ($T_m = 110°$) (ref. 10) bonds would have a T_m 20–25 deg. higher than an equivalent helix with only adenine-uracil bonds. Since ribonucleic acid can be expected to have many helical regions with at least this degree of content of guanine-cytosine bonds, it appears safe to conclude that these regions will be stable at 25° C. even if they contain as much as one-third of their residues looped outside the helix. Thus, loops permit a greatly increased incorporation of adenine-uracil and guanine-cytosine pairs into helical regions.

The Minimum Helix Size : Before exploiting the degree of freedom that loops provide in ribonucleic acid, one other restraint must be noted. Even without loops, the T_m of a given helical structure will decrease with decreasing length and will at some value pass below some temperature of interest, say 25° C. Current experiments (Fresco, J. R., Blake, R., and Doty, P., unpublished observations; also ref. 13) in which T_m has been determined for various helical complexes of long-chain poly-uridylic acid, and uniform oligonucleotides of adenylic acid show that T_m becomes equal to about 25° for the tetraadenylic acid. Again, this may be lowered still more if the long-chain poly-uridylic acid is replaced by a short oligo-uridylic acid. But, as before, the existence of guanine-cytosine bonds in ribonucleic acid will probably more than compensate for such weakening effects. Hence, we can estimate that the minimum size of helical regions stable at 25° C is about four nucleotide pairs, and that six nucleotide pairs, for example, would probably accommodate at least three looped-out residues at 25°. This, then, defines helical regions of minimum stability. Since the major part of the melting curve for all samples of ribonucleic acid occurs between 20° and 90°, it would be expected that the majority of helical regions in ribonucleic acid are longer or have a smaller percentage of loops.

Summary of the Features involved in the Secondary Structure of Ribonucleic Acid : The three points discussed above can be combined with the relevant observations of the earlier work to provide a summary of the behavioural characteristics of ribonucleic acid which should govern the elaboration of its secondary structure. The experimental support for these points is now fairly substantial, although further work can be expected to lead to minor revisions.

(1) Ribonucleic acid is a single-stranded molecule[14–17] the secondary structure of which arises from intramolecular interactions.

(2) The most stable of several possible secondary structures is the two-stranded helix of the deoxyribonucleic acid type in which adenine-uracil and guanine-cytosine pairs are hydrogen-bonded. The guanine-cytosine pair, being stronger, is preferred.

(3) At 25° and moderate ionic strength, the minimum length of helix without loops is about four nucleotide pairs.

(4) Under the above conditions, if the helical region contains an approximately equal quantity of adenine-uracil and guanine-cytosine bonds, six nucleotide pairs can accommodate at least three looped residues (one fifth of the total involved). Longer regions can have up to one-third of their residues looped out from the helical structure without destroying their stability.

(5) Ribonucleic acid takes up its most stable conformation as a result of a lateral mobility which permits exploration of most competitive conformations[12,18,19]. The chain adjustment made possible by the looping of residues in helical regions is a vital part of this process.

(6) The most stable helical regions arise from interactions between adjacent sections of the polynucleotide backbone. Entropy considerations suggest that interactions between distant sections are unlikely, since they would lead to very highly restrictive conformations. Thus, the helical regions take the form of hairpin turns which require a minimum of three unbonded nucleotides to connect the antiparallel hydrogen-bonded chain sections. The spatial parameters of the helix are probably close to those determined for poly-(adenylic + uridylic acids)[20].

Illustrations of Secondary Structure : Our proposal is that this set of conditions is sufficient to indicate the essential nature of the deployment of nucleotides in the characteristic conformation of ribonucleic acid. The kind of structure that develops from these conditions can be illustrated in two ways. In one we can take a short sequence of nucleotides chosen at random from an equimolar mixture and work out all conformations compatible with the above conditions. In another we can take a much longer sequence and show typical conformations which satisfy these conditions but may not represent the optimal conformation.

The first approach is summarized in Fig. 1. Here a particular random sequence of 22 nucleotides has been examined. Without the possibility of loops, the longest helical region has only three adjacent base pairs and is therefore below the stability condition specified. When loops are permitted, however, 7 adjacent base pairs can be formed, resulting in 63 per cent of the bases being in the helical region. Indeed, the average of all conformations is 6 pairs, or 54 per cent, of the nucleotides in helical regions, all above the minimum size permitted.

In the second example, we have taken a random sequence of 90 nucleotides, thus using a size comparable with that occurring in transfer ribonucleic acid. If one attempts to obtain maximum length of the helix, results such as that in Fig. 2 are obtained. Here 60 per cent of the bases are paired, but in the central section the concentration of loops is so high that this section would not remain helical according to the above conditions. Consequently, only about 40 per cent of the bases could be paired. Alternatively, one can explore many other conformations and these lead

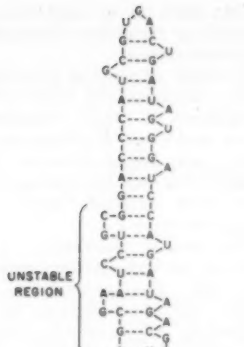


Fig. 2. A less probable arrangement for a hypothetical ribonucleic acid chain

to results such as that shown in Fig. 3. Here there are three helical regions all exceeding the conditions of minimum stability, and 58 per cent of the bases are paired. In all cases examined, these helical regions were less than twelve nucleotide pairs in length and had only very short unbonded sections between them. Indeed, we have found that such short helical regions generally lead to the most stable conformations, since they make possible the greatest amount of chain adjustment and thereby satisfy the tendency towards maximum hydrogen bonding[13,18,19]. Thus the conformation in Fig. 3 is typical of a closely related group that is permitted by the above set of conditions and it is representative of the more specific definition of secondary structure in ribonucleic acid that we propose.

It should be emphasized that in the present treatment we have had to assume a random sequence of nucleotides in ribonucleic acid, because of the absence of definite information on this point. It is much more likely, however, that the actual sequences in individual ribonucleic acid molecules deviate from randomness, and in such ways that the amount and the stability of the helical regions are either greater

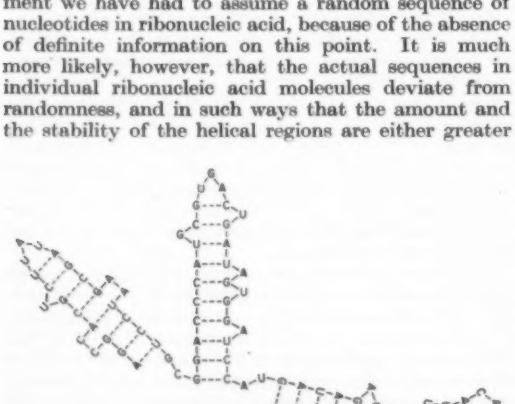


Fig. 3. A more probable arrangement for a hypothetical ribonucleic acid chain

or less than those obtained with our assumption. Thus, while the helical content and stability that we have estimated do approximate to those found in a number of ribonucleic acid samples, nevertheless the accuracy of our estimates is limited by the assumption of random sequence.

Discussion : Having arrived at this view of the secondary structure of ribonucleic acid, one must ask if it is compatible with what is known about that substance, and if there is any direct test of the structural proposal. In the first category there are three relevant data : those purporting to estimate the helical content, those dealing with size and shape and their dependence upon ionic strength, and those derived from X-ray diffraction.

Since in our model the fraction of bases in helical regions does lie in the vicinity of 60 per cent, agreement with the earlier estimates of helical content has been achieved. In addition, the range of temperature in which the helical regions melt is that expected from a polynucleotide having a series of helices that deviate in varying degrees from long, perfect helices involving the adenine-uracil and guanine-cytosine pairs.

Hydrodynamically, ribonucleic acid molecules behave as randomly coiled chains[4,6,15–17] ; but this behaviour, as reflected in the dependence on molecular weight of the sedimentation-rate and the intrinsic viscosity, would also be expected from the model discussed here, since the mass distribution averaged over all orientations would probably approximate to a Gaussian distribution, as does a random coil. A more discriminating observation is that ribonucleic acid does now show a *strong* polyelectrolyte effect at *moderate* ionic strength[17], that is, it does not expand sharply with decreasing salt concentration. In fact, any expansion that does occur is accompanied by a simultaneous loss of some helical structure[6,9]. Thus, there do not appear to be many nucleotides in flexible chain regions except those that are liberated from previously disrupted helical regions. The model proposed here would behave similarly, since the random regions between the helices are very short, and most of the remaining nucleotides that are not hydrogen-bonded are in loops that can display only slight conformational response to changing ionic strength.

The last kind of observation to be considered is that of X-ray diffraction. The early diffraction studies[21] did not contribute much to our knowledge of the secondary structure of ribonucleic acid, although the reflexions were such as not to conflict with a helical structure. Current investigations by Zubay, Wilkins and Brown (ref. 22 and Brown, G., personal communication) have yielded much more definitive diffraction patterns for both ribosomal and transfer ribonucleic acid, and in each case they obtain considerable evidence for the deoxyribonucleic acid type helical regions which were proposed earlier[3,4]. These recent observations neither support nor contradict the looping feature of our model ; but it is probably in this method, with the use of specially prepared polynucleotide helices, that a direct test of this feature can be made.

It may be useful at this point to make some general remarks about possible relations between the secondary structure of ribonucleic acid proposed here and the structural requirements for the functioning of ribonucleic acid. In the absence of specific information, two kinds of activity must be visualized for

ribonucleic acid. In the particular case of transfer ribonucleic acid, the specificity of amino-acid uptake may be due in part to the stabilized topology of a portion of the ribonucleic acid molecule in the vicinity of the acceptor end. This model provides adequate possibilities in this direction.

In ribosomes, ribonucleic acid must maintain stable connexions with the protein component so that a swollen matrix is preserved. While little appears to be known about the details of this organization, two recent observations suggest that our model is relevant to ribonucleic acid within the ribosomes. One is that the hydrogen-bond content of ribonucleic acid within the microsomes is similar to that estimated for the isolated ribonucleic acid[17,23]. The other is that the X-ray diffraction pattern of ribosomes bears a close similarity to that of the isolated ribonucleic acid, once the protein diffraction is subtracted[23]. Consequently, we can visualize that the unpaired bases in the loops or in open-chain regions provide potential sites for structural connexions with amino-acid residues of the ribosomal protein. Of course, the more significant role of ribonucleic acid in the ribosome would appear to be that of recognition of an incoming transfer ribonucleic acid–amino acid molecule, its momentary deposition at a particular locus, and its later ejection. The stability of many of the helical regions in ribosomal ribonucleic acid at cell temperature is marginal, and thermal fluctuations might well lead to the momentary opening of a significant proportion of the regions envisaged in our proposal. In that event the complementary region of the transfer ribonucleic acid molecule could readily be accepted by base-pair interactions, resulting in a short helical region. Subsequent disruption of this helical region at the time of a later thermal fluctuation, perhaps resulting from the formation of peptide bonds, might provide a means of return to the former state with the liberation of the temporarily bound ribonucleic acid molecule. Such possibilities are clearly inherent in the helical structure described here.

In concluding, we would like to emphasize that the secondary structure of ribonucleic acid that we have detailed is dictated to each molecule by its own nucleotide sequence; and that the unpaired bases in these molecules constitute a tertiary structure, in that they are in most cases held in fixed relation to each other either on the same helical region or on different ones. This provides for new possibilities in coding and information transfer that are not inherent in a structureless single strand or in a perfect base-paired helix.

This work has been supported by grants from the United States Public Health Service, *C*–2170, and from the American Heart Association.

[1] Watson, J. D., and Crick, F. H. C., *Nature*, **171**, 737 (1953).
[2] Pauling, L., and Corey, R. B., *Proc. U.S. Nat. Acad. Sci.*, **37**, 235 (1951).
[3] Doty, P., Boedtker, H., Fresco, J. R., Haselkorn, R., and Litt, M., *Proc. U.S. Nat. Acad. Sci.*, **45**, 482 (1959).
[4] Doty, P., Boedtker, H., Fresco, J. R., Haselkorn, R., and Hall B. D., *Ann. N.Y. Acad. Sci.*, **81**, 693 (1959).
[5] Cox, R. A., and Littauer, U. Z., *Nature*, **184**, 818 (1959).
[6] Gavrilova, L. P., Spirin, A. S., and Belozersky, A. N., *Doklady Akad. Nauk SSSR*, **126**, 1121 (1959).
[7] Haschmeyer, R., Singer, B., and Fraenkel-Conrat, H., *Proc. U.S. Nat. Acad. Sci.*, **45**, 313 (1959).
[8] Boedtker, H., *J. Mol. Biol.* (in the press).
[9] Lipsett, M. N., *Proc. U.S. Nat. Acad. Sci.*, **46**, 445 (1960).
[10] Marmur, J., and Doty, P., *Nature*, **183**, 1427 (1959).
[11] Tissières, A., *J. Mol. Biol.*, **1**, 365 (1959). See also Cox, R. A., and Littauer, U. Z., *ibid.*, **2**, 166 (1960).
[12] Fresco, J. R., and Alberts, B. M., *Proc. U.S. Nat. Acad. Sci.*, **46**, 311 (1960).
[13] Lipsett, M. N., Heppel, L., and Bradley, D. F., *Biochim. Biophys. Acta*, **41**, 175 (1960).
[14] Gierer, A., *Nature*, **179**, 1297 (1957).
[15] Boedtker, H., *Biochim. Biophys. Acta*, **32**, 519 (1959).
[16] Hall, B. D., and Doty, P., *J. Mol. Biol.*, **1**, 111 (1959).
[17] Hall, B. D., and Doty, P., in "Symposium on Microsomal Particles and Protein Synthesis", edit. Roberts, R. B., 27 (U.S. Academy of Sciences, 1958).
[18] Felsenfeld, G., and Rich, A., *Biochim. Biophys. Acta*, **26**, 457 (1957).
[19] Felsenfeld, G., *Biochim. Biophys. Acta*, **29**, 133 (1958).
[20] Rich, A., and Davies, D. R., *J. Amer. Chem. Soc.*, **78**, 3548 (1956).
[21] Rich, A., and Watson, J. D., *Proc. U.S. Nat. Acad. Sci.*, **40**, 759 (1954).
[22] Zubay, G., and Wilkins, M. H. F., *J. Mol. Biol.*, **2**, 105 (1960).
[23] Schlessinger, D., *J. Mol. Biol.*, **2**, 92 (1960).

REPORT OF THE TELEVISION ADVISORY COMMITTEE, 1960

THE Television Advisory Committee, set up in October 1952 under the chairmanship of Admiral Sir Charles Daniel, had as terms of reference: "To advise the Postmaster General on the development of television and sound broadcasting at frequencies above 30 megacycles per second and related matters, including competitive television services and television for public showing in cinemas and elsewhere". The Committee has now issued its third report* (the earlier reports were issued in 1953 and 1954 respectively) and is concerned entirely with possible ways of allocating wave-bands to alternative programmes, and with possible new scanning-line standards to link up Britain with the rest of Europe. Colour television also is briefly referred to, but nothing new is said, though a later report on this specific subject will be issued by the Committee "as soon as they are in a position to do so".

The questions discussed in the present report are wholly technical, but even within this limited sphere it is a rather disappointing document. The various technical questions cannot fully be answered, as this Committee of course realized, without relating them to broader matters—a national programme policy, types of material and picture quality really needed, the degree of programme exchange with Europe (or, shortly, with the whole globe), the relative needs and urgencies of other services' demands on æther space, financial questions and many others. Thus it is good to find that the Postmaster General has at last announced the appointment of the long awaited committee to inquire into the future of broadcasting and television in the country; this new committee, under Sir Harry Pilkington, has the broadest terms of reference, covering all aspects of policy. It has been asked by the Postmaster General to consider this present technical report of the Television Advisory Committee; perhaps the new committee will take its technical inquiries a little further too.

Never again, in all probability, shall we in Britain have the opportunity to re-think the whole fundamentals on which our television service rests.

* General Post Office. Report of the Television Advisory Committee, 1960. Pp. 20. (London: H.M. Stationery Office, 1960.) 1*s.* net.

Thus we are forced to reconsider now, for several reasons; Surely we should seize our opportunity and act boldly, with the kind of enterprise and initiative which British industry showed in the 1930's when it took the world lead in television development? At that time we had reached our first point of departure and broke away from earlier television history, with its mechanical standards, to develop a whole new electronics industry. We have surely reached a similar point to-day. For we have the colour-television question forced on us, we have integration with Europe (and we should not restrict this to Europe, but adopt a global view now, with the techniques likely to emerge during the next twenty-five years, being the period under consideration by the Committee); and we have the æther congestion problem; we have a host of new techniques as yet unused.

Something has to be done at this point. Cannot we again break away from tradition and think boldly? We go on transmitting nearly identical frames 50 times a second, to be viewed on traditional (though improved) cathode-ray tubes; Is there no alternative? We go on speaking of wave-bands and other Fourier-like concepts, rather than of probabilities and information-rates. Cannot we devise a new kind of camera with much lower noise figures, and then take advantage of coding schemes? Is it inconceivable to develop receivers with cheap 'memories'? Endless such questions can be raised; it is all very well for a mere academic like myself to raise them, but the overriding question is: Has British industrial inventiveness vanished in this field where once it was so prominent?

The main conclusions of the present report of the Television Advisory Committee may be illustrated by the following table, which defines the four 'bands' which are at present available:

Band	Range (Mc./s.)	
I	41–68	At present used by five B.B.C. channels.
III	174–216	Half this range used by four I.T.A. channels.
IV	470–582	Not at present used, but propagation and other field-trials carried out.
V	606–960	

Nearly half band V has been appropriated already for tropospheric scatter links, leaving only the range 606–800 Mc./s. for possible use for television.

Apart from France, Eire and Britain, 625 lines are standard in Europe, both east and west. It seems wise for us to adopt the same, for our broadcasts will become increasingly integrated with those of Europe (though this is too restricted in my view). The conclusion offered is that, if 625 lines be adopted, the number of alternative programmes offered to the public cannot be increased, unless we spill over into the experimental bands IV and V. Dreams of a third programme begin to fade.

However, the Technical Sub-Committee advises that *if* television be confined to bands I and III, we *could* have a third programme working on 625 lines if we limit our channel spacing to 7 Mc./s. This point seems to me to be crucial. For the European standard bands are not 7 but 8 Mc./s., which we are told is needed for full picture quality on 625 lines. How can we get 8 Mc./s. into a 7 Mc./s. pot, and so put three programmes where two stand at present? By compression.

This word 'compression' is not mentioned at all in the present report. Throughout, it is accepted without question that picture quality depends solely upon band-width; it does not. We may not expect the Committee to recommend specific systems of recoding for band-width compression; far too little is understood yet, but it is a thousand pities it has not recommended urgent studies of the subject. Television by present techniques is about as wasteful of band-width as can be; we still have not learnt the lessons of statistical communication theory.

Calculation of signal information redundancy is one thing; invention of techniques for utilizing the results is quite another. Many writers have referred to television signals as being ten-to-one, hundreds-to-one, redundant, but this is going much too far at present. But to compress band-widths in fractional ratios of 7/8 or even, say, 2/3 raises no fundamental difficulties; and there need be no complexity of apparatus in the receiver, for coder and decoder need not be 'mirror-images'.

British industry is doing little about this, to the best of my knowledge. It needs development of new types of low-noise camera and multiplier, of storage systems, of new kinds of time-base particularly. Moreover, the implications of such work extend into many fields other than television. Again, it is conceivably possible to develop systems which would be compatible with existing receivers (by substitution of parts only, such as time-bases).

Whatever changes are proposed, compatibility must be considered, as this report rightly stresses, because some £600 million is tied up in existing receivers in Britain alone. The capital invested in the whole industry is gigantic. This report emphasizes the view so commonly expressed, that 'higher picture quality' necessarily means greater 'detail' (that is, adhesion to realism). If only we could educate the public to accept certain visual conventions and forms, how much we might save by coding techniques! It is a curious divergence, that while modern art does just this, in its abstracting out of reality, our mass-cultures such as television forever seek greater realism like the Victorian painters. This process is to-day very expensive.

Colin Cherry

OBITUARY

Prof. W. H. Lang, F.R.S.

By the death of William Henry Lang on August 29 botanists have lost one of the most distinguished plant morphologists of this century. Born in 1874, Lang was educated in Glasgow and entered the University in 1889, where he studied science and medicine, graduating M.B., C.M., with high commendation in 1895. He had in the previous year while a medical student graduated B.Sc. with honours in botany and zoology. In 1900 he graduated D.Sc. and in 1932 the University conferred on him an honorary LL.D. In 1895 he was awarded a Robert Donaldson scholarship which enabled him to work on apogamy in ferns at the Jodrell Laboratory at Kew where D. H. Scott was then keeper. After returning to Glasgow he was appointed lecturer in Queen Margaret College in the University and continued research on ferns and on cycadean sporangia. His work on ferns was undoubtedly stimulated by his association with

Prof. F. O. Bower and his fellow lecturer and great friend Gwynne-Vaughan. He also worked on Hepaticae and published in 1901 a paper on apospory in *Anthoceros*: this was followed by other papers on *Cyathodium*, *Notothylas*. He continued research on Pteridophyta and made important contributions to our knowledge of the gametophytes of the Ophioglossaceae. In 1909 he produced an exceptionally interesting paper on a theory of alternation of generations in Archegoniatae, based on ontogeny, which led to an organized discussion on "Alternation" at the Linnean Society.

His appointment in the same year as first occupant of the Barker chair of cryptogamic botany in the University of Manchester provided him with much greater opportunity for research. Prof. F. E. Weiss, who occupied the chair of botany, was a most sympathetic and helpful colleague, and Lang had practically no administrative work. He gave lectures, only to the honours students, on cryptogams. In 1910 he went on an expedition with A. G. Tansley to Ceylon and Malaya to study tropical Cryptogams. On returning he continued work on the morphology of the Ophioglossaceae and between 1910 and 1914 published four papers in the *Annals of Botany*. In 1914 and 1915 there appeared in the *Memoirs of the Manchester Literary and Philosophical Society* his "Studies in the Morphology of *Isoëtes*", probably one of the most difficult subjects on which he had worked. The complex anatomy of the plant and its curious method of growth presented particularly difficult problems. Lang's descriptions are for the most part clear and unambiguous, but it requires close concentration on the part of the reader to follow his comparisons between the stelar morphology of *Isoëtes* and that of other Pteridophyta. It was perhaps his most notable work up to that date.

The discovery by Dr. W. Mackie, of Elgin, of petrified plants in an astonishingly good state of preservation in chert of Middle or Lower Devonian Age in Aberdeenshire had far-reaching results. The investigation of the Rhynie fossils was carried out by Kidston and Lang. They commenced publication of their results in 1917 in the *Transactions of the Royal Society of Edinburgh* and completed it in 1921, when they gave an account of their discovery at the meeting of the British Association in Edinburgh. These memoirs on the Rhynie plants are models of accuracy in description and restraint in phylogenetical speculation. Lang was aware of the importance and significance of these discoveries and their bearing on problems of evolution and comparative anatomy, but wisely left it to others to indulge in speculation on the course of evolution of vascular plants. Later discoveries by him and others of complex Silurian and Lower Devonian plants fully justify the restraint shown by Kidston and Lang, whose names will always be associated with this, the most important contribution of the century to our knowledge of early plant life.

Those who were privileged to know and work in the same laboratory will remember him as a most exceptionally gifted man with many and varied interests not only in science but also in literature and the Fine Arts. He was extremely friendly and helpful, and his junior colleagues have reason to remember him with great respect and affection.

JOHN WALTON

NEWS and VIEWS

Physiology at Birmingham : Prof. H. P. Gilding

PROF. HENRY PERCY GILDING, who is retiring from the chair of physiology in the University of Birmingham, graduated at Oxford in 1923 and in the same year entered on a distinguished undergraduate and postgraduate career at St. Bartholomew's Hospital Medical College where, while the Department of Physiology was without a professor, he had charge of the teaching of physiology and the administration of the Harvey Laboratories. In 1928 he was a Fellow of the Rockefeller Institute, New York, where he carried out research with Dr. Peyton Rous. He returned to London to join the Physiology Department at University College and in 1932 was appointed reader. At University College he continued his researches on the circulation of the blood and on lymph and his interest in the applications of physiology was shown by his tenure of a research post with the Medical Research Council and the Thomas Young lectureship in clinical physiology at St. George's Hospital Medical School. When he was appointed to the chair of physiology in Birmingham in 1933, Gilding made great use of the opportunities given to him for planning and organization in the building of the new Medical School. He is well known for his interest in medical education, and when teaching in the new School was established, he initiated the scheme of integrated teaching of physiology and anatomy by co-operation between the two Departments which has attracted so much attention. When the Goodenough Committee was considering developments in medical education he played an active part in obtaining increased facilities for honours courses in physiology for medical students. A great demand for his services as an external examiner is not only a consequence of this interest but also a tribute to his personal qualities. He has for many years given useful service to the Physiological Society as a member and chairman of its Committee, as its treasurer and as its representative on the Council of International Abstracts of Biological Sciences. He served as a member of the Council of the British Association and was recorder and later president of its Section I (Physiology). Gilding saw much active service in the First World War which interrupted his undergraduate career and he was for a time a prisoner of war.

Prof. Ian E. Bush

DR. IAN E. BUSH has been appointed to succeed Prof. Gilding. He went from Bryanston School to Pembroke College, Cambridge, and was awarded first class honours in Natural Sciences Tripos Part 2 (Physiology) in 1949. The grant of a Medical Research Council scholarship in 1949 enabled him to work in the Physiology Laboratory, Cambridge, until 1950, when he moved to the National Institute for Medical Research, where he stayed until 1952. The degree of Ph.D. (Cantab.) was conferred in 1952. A Commonwealth Fund Fellowship provided the opportunity for him to travel to the United States, where he

worked in the Biological Chemistry Department, University of Utah, and later at the Huntington Memorial Laboratory, Massachusetts General Hospital. In 1953 he became a medical student and part-time research assistant to the Medical Unit at St. Mary's Hospital, London. In 1956 he moved to Oxford with Sir George Pickering on the latter's appointment to the regius chair of medicine. He qualified M.B., B.Chir. (Cantab.) in 1957. He was placed in charge of a group for research into humoral physiology and pathology under Sir George Pickering. This work has attracted the support of the Medical Research Council and the Rockefeller Foundation. He has published numerous papers on steroid metabolism and is particularly well known for his able use of chromatography in the analysis of steroids in general.

Science Adviser to the U.S. Secretary of State

Dr. Walter G. Whitman, formerly chairman of the Department of Chemical Engineering of Massachusetts Institute of Technology, has been appointed science adviser to the U.S. Department of State, in succession to Wallace R. Brode, who has resigned. Dr. Brode, who has a long record of government service with various scientific agencies, has been serving as science adviser to the Secretary of State since January 1958. A science adviser and a number of science attachés at posts abroad were first appointed in 1951. During his tenure as science adviser, Dr. Brode revitalized the entire science attaché scheme. Ten embassies abroad have been staffed with science attachés, many of whom cover a number of countries on a regional basis. These attachés facilitate scientific exchanges with the United States, and interpret American science to scientists, science writers, editors, and others who influence foreign attitudes toward the United States, and its scientific and technological achievements. Further, as a function of prime importance to the Department of State, they help other members of the embassy staffs to give proper consideration to the scientific and technical factors involved in the decisions they must make.

Dr. Whitman, the new science adviser, served with the National Advisory Commission for Aeronautics during 1940–45, was director of the Lexington Project of the Atomic Energy Commission in 1948, and also served as secretary-general for the United Nations Conference on the Peaceful Uses of Atomic Energy in 1955. He was chairman of the Research and Development Board of the Department of Defense during 1951–53 and was a member of the National Advisory Commission for Aeronautics during the same two years. He is on terminal leave from the Massachusetts Institute of Technology.

British Steel Castings Research Association: Appointments

The British Steel Castings Research Association, Sheffield, has announced the following new appointments. Mr. C. M. Stoch to be assistant director of research. Mr. Stoch, who joined the Association in 1951, has been in charge of the Plant Engineering and Industrial Health Section since 1953, and for the past two years has also been acting head of the Steelmaking Section. He was born in Poland, and, after having graduated in 1937 in metallurgy at the University of Krakow, he worked in the steelmaking department of the Baildon Steelworks, Katowice. He was called to the Forces in 1939 and took part in the fighting in Poland, rejoined the Polish Forces in France in 1940 and afterwards in Great Britain. Mr. Stoch has recently been investigating the development and improvement of dust control devices on grinding machines and fettling benches. Mr. K. Knaggs, deputy head of the Association's Steelmaking Section for the past two years, has been appointed head of this Section.

Joint British Committee for Electron Microscopy

A Joint British Committee for Electron Microscopy has been set up with the following three objects in mind: first, to co-ordinate meetings in the whole field of electron microscopy, including the design, use and application of the instruments, and of cognate subjects arranged by its constituent bodies; secondly, to encourage the holding of joint meetings by its constituent bodies; thirdly, to act in the collective interest of the constituent bodies by maintaining liaison with the International Federation of Electron Microscope Societies and with National Societies covering this field, and also by maintaining liaison with oversea societies concerned with electron microscopy. Dr. V. E. Cosslett, University of Cambridge, has been elected the first chairman of the Committee. The foundation members are as follows: the Anatomical Society of Great Britain and Ireland; the Physics Group of the Textile Institute; the Biochemical Society; the Royal Microscopical Society; the Chemical Society; the Institute of Physics and the Physical Society; the Society for Experimental Biology; the Iron and Steel Institute; the Society for General Microbiology; the Linnean Society; the Pathological Society of Great Britain and Ireland; the Institute of Metals. Other societies interested in electron microscopy are welcome to adhere to this Committee. Further information can be obtained from the General Secretary, Royal Microscopical Society, Tavistock House South, Tavistock Square, London, W.C.1.

Funds for Basic Research in the United States: 1959–60

Estimates by the National Science Foundation in "Reviews of Data on Research and Development", No. 22, put total funds for basic research in the United States in 1959–60 at 1,000 million dollars, compared with 430 million dollars in 1953–54 and 830 million dollars in 1957–58. Throughout this period funds for basic research were about 8 per cent of the total funds available for research and development. In 1957–58 expenditure on basic research by colleges and universities was 392 million dollars, an increase of 88 per cent on 1953–54, corresponding expenditure by the Federal Government being 111 million dollars (an increase of 136 per cent) and by industry 272 million dollars (80 per cent increase). The Federal Government, however, supplied 423 million dollars of the total funds for basic research and industry 249 million dollars, although these figures represent only 7 per cent of the total research and development funds from each of these sources. Of Federal funds for basic research in 1957–58, the universities and colleges received 57 per cent (compared with 61 per cent in 1953–54), industry 10 per cent (10 per cent in 1953–54), other non-profit institutions 7 per cent (5 per cent in 1953–54) and Federal Government institutions 26 per cent (24 per cent in 1953–54). Of the total 835 million dollars, 282 million dollars went to the biological and 553 million dollars to the physi-

cal sciences, of which 195 million and 197 million dollars, respectively, were in the universities and colleges; for industry the corresponding figures were 27 million and 245 million dollars, respectively; for other non-profit institutions, 27 million and 33 million dollars; and for Federal Government institutions, 33 million and 78 million dollars. For 1953–54, the corresponding figures are: colleges and universities, 92 million and 116 million dollars; industry, 9 million and 142 million dollars; other non-profit institutions, 14 million and 12 million dollars; and for Federal Government institutions, 17 million and 30 million dollars.

The Indian Potato Journal

The Indian Potato Journal, issued by the Indian Council of Agricultural Research (1; April 1959. Ed., P. L. Jaiswal. New Delhi. Rs. 6.00 per annum) as a half-yearly periodical, will be devoted exclusively to the improved cultivation of this crop. The journal contains original scientific papers, general articles and reviews of relevant research. Thus, in Vol. 1, No. 2, there are contributions on such topics as the effect of nitrogen fertilizers on the yield and chemical composition of potatoes; the crossability of diploid *Solanum* species; growth and tuber formation; control of sprouting by growth regulators; Kashmir as a potential seed potato area.

Geodesy and Artificial Satellites

In a recent issue of *Smithsonian Contributions to Astrophysics* (3, No. 9. Pp. iv+95–161. (Washington, D.C.: Government Printing Office, 1960.) 65 cents), entitled "Geodetic Uses of Artificial Satellites", G. Veis gives a detailed mathematical exposition of methods for extracting geodetic information from observations of artificial satellites. Most of the geodetic results so far obtained from satellites have stemmed from their orbital perturbations; this paper lays the foundation for the satellites' other role, when they act as aerial triangulation points and can be utilized directly, without the intervention of dynamical theory. A second recent publication on this topic is "Use of Near-Earth Satellite Orbits for Geodetic Information", by P. D. Thomas (Technical Bulletin No. 11 of U.S. Coast and Geodetic Survey. Pp. ii+36. (Washington, D.C.: Government Printing Office, 1960.) 45 cents). This is a lively and rather informal review of results up to the end of 1959 on the Earth's flattening, which satellites have shown to be 1/298·2 rather than 1/297, as previously believed. The paper also discusses the methods of observing satellites and some related topics.

Fluctuations in the Level of the Caspian Sea

The level of the Caspian Sea (*Nature*, 179, 1112; 1957), after many years of fall, in 1957 began to rise in spite of a marked decrease in the inflow of the river water. According to B. G. Richter (*Priroda*, 2, 45; 1960), this rise can be explained by the nature of the tectonic movements occurring in this region, and which tend to alter the volume of the hollow in which the Caspian Sea is situated. A map showing areas of elevation and areas of sinking explains the relative rapid rise of the land in the region of Baku and in parts of the eastern shore of the Caspian Sea, especially the rapid drying up of the salt-producing bay of Kara-Boghaz-Gol (*Nature*, 179, 409; 1957), which is discussed by V. D. Polyakov (*Priroda*, 3, 93; 1960).

Protease Inhibitor in Human Blood

Serum trypsin and chymotrypsin inhibitors have been determined with reasonable accuracy by a modified ultra-violet absorption method. The serum examined was diluted thirty times with normal saline. N. Aizawa reports in the April issue of the *Yokohama Medical Bulletin* that both inhibitors were found to be stable below 3° C. for about fifty days, and that 20 per cent of trypsin inhibitory activity was maintained even after heating at 60° C. for 30 min. On the other hand, inhibitory activity against chymotrypsin completely disappeared under the same conditions. It seems difficult to conclude that both inhibitory activities are exerted by a single inhibitor. Further experiments showed that the trypsin inhibitory principle was found to pass gradually through a 'Cellophane' membrane; it is probable that the inhibitory factor is a relatively lower molecular substance than hitherto supposed. From the fact that trypsin inhibitory activity was recovered by neutralization, even after the incubation of the serum for 24 hr. at less than *p*H 5·0, the *p*H inactivation may be a reversible change.

The Stone Age in Jersey: Saint Brelade's Cave

Saint Brelade's Cave in Jersey, British Channel Islands, has long been known as an important prehistoric site of the Stone Age. Following some preliminary digging it was partially excavated by the late Dr. R. R. Marett in 1913, but the First World War stopped the work, and though it was continued later, the bottom layers were never reached. An important Mousterian industry was, however, unearthed. Recently, Father Christian Burdo has re-examined the site, and excavated the lower layers where he has found an Acheulean assemblage. Dr. Zeuner dates the cave infilling to a period from the end of the Riss glaciation to the start of the Würm. The Société Jersiaise has published an excellent account of the finds which can be obtained from the Museum, 9 Pier Road, Jersey (Excavation of a Pre-Mousterian Horizon, 1950–1958. Pp. 77+8 plates. (Jersey, Ch. Is.: Société Jersiaise. 7*s*.)). Several of the implements are illustrated, and a list of the fauna and flora found given. There are also some excellent full-page photographs of the site itself.

James Picker Foundation: Radiological Research Awards

On behalf of the James Picker Foundation, the National Academy of Sciences–National Research Council is accepting applications for fellowships and grants in the field of radiology and nuclear medicine for the year 1961–62. The awards are made in four categories: *Advanced Fellowships in Academic Radiology*, offered for the first time during the past year, the purpose of which is to prepare the candidate who has completed his or her clinical training in radiology to meet in full the intellectual demands of an academic position in radiology; *Postdoctoral Fellowships in Radiological Research* are open to recent graduates who desire experience and training in scientific investigation, and while these awards are for a period of one year, requests for renewal will be considered; *Grants for Scholars* are a transitional form of support, designed to bridge the gap between the completion of research fellowship training and the period when the young scientist has thoroughly demonstrated his competence as an independent

investigator, and while the initial grants are limited to one year, renewal for two additional years may be recommended; *Grants-in-Aid of Research* are designed to encourage investigations offering promise of improvement in radiological methods of diagnosis or treatment of disease and are awarded to institutions, rather than to individuals. Applications in these four categories will be reviewed by the Committee on Radiology of the Academy–Research Council's Division of Medical Sciences. Final determination of awards is made by the Foundation on recommendation of the Division. These awards are not restricted to citizens of, or laboratories within, the United States. Application forms and further details can be obtained from the Division of Medical Sciences (Room 305, *AAUW*), National Academy of Sciences–National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D.C. Applications must be submitted by December 1, 1960.

The Royal Institution of Naval Architects

The Council of the Royal Institution of Naval Architects has made the following awards: *Royal Commissioners for the Exhibition of* 1851 *Postgraduate Scholarship in Naval Architecture* (1960), £600 per annum for two years, to Mr. B. S. Bowden, of King's College, Newcastle upon Tyne; *The Royal Institution of Naval Architects Scholarship in Naval Architecture* (1960), to Mr. M. A. Cubitt, of Messrs. Vosper, Ltd., Portsmouth (£400 per annum for three years at King's College, Newcastle upon Tyne); *Vickers-Armstrongs Scholarship in Naval Architecture* (1960), to Mr. Brian T. Procter, of Trinity Academy, Edinburgh (£400 per annum for four years at the University of Glasgow).

Naval Radiological Defense Laboratory

The Naval Radiological Defense Laboratory in San Francisco has created a new position with the title of 'scientist-in-residence'. The scientist appointed will be expected to work on a matter of his own choosing within broad categories of the Laboratory's field of interest, which are the basic thermal and ionizing radiations from all types of nuclear reactions, their chemical, physical and biological effects, both topical and environmental, and ways of predicting, preventing or minimizing them. Candidates should have demonstrated superior ability for creative research. It is a full-time appointment, normally for one year. Two places are available this year; later there may be six. Applications should be addressed to Scientist-in-Residence Committee, U.S. Naval Radiological Defense Laboratory, San Francisco 24, California.

Natural Resources in Scotland

The Scottish Council's Committee on Natural Resources is holding a symposium on "Natural Resources in Scotland" at the Royal Society of Edinburgh, 24 George Street, Edinburgh, during October 31–November 2. The three days will be devoted as follows: first day, "Basic Resource Facts"; second day, "Utilization of Resources"; third day, "Resource Administration and Development". The chairmen on each of the three days will be: the Rt. Hon. Lord Bilsland (president, Scottish Council, and Development and Industry), Sir Cecil M. Weir (chairman, London Executive Committee, Scottish Council, and Development and Industry), Sir Edward Appleton (principal, University of Edinburgh). Further information can be obtained from the Organizing Secretary, The Scottish Council (Development and Industry), 1 Castle Street, Edinburgh, 2.

William Thomas Brande

Mr. E. E. Ironmonger, Westminster College, North Hinksey, Oxford, writes: "I am collecting information concerning the life and work of William Thomas Brande (1788–1866), who was professor of chemistry at the Royal Institution during 1813–52 and secretary to the Royal Society during 1816–26. I should be glad to hear of any letters, manuscript material, etc., of which readers of *Nature* may have information".

Announcements

Mr. A. V. S. de Reuck, formerly assistant editor of *Nature*, has been appointed deputy director of the Ciba Foundation for the Promotion of International Co-operation in Medical and Chemical Research, London. Miss M. P. Cameron has returned to the Ciba Foundation as scientific assistant and librarian after five years in the United States.

The first award of the Ellis Medal of the Institution of Works Managers goes to Mr. W. Huddleston, of the Springfields Atomic Factory, Salwick, Lancs. The Ellis Medal commemorates the work of John Milton Ellis, who helped to establish the Institution's training course, and will be awarded annually to a student of the Institution, under the age of thirty, who, having qualified at the end of the two-year course in works management, satisfies the assessors that he has most fully appreciated the practical implications of the training he has received in the art and science of works management.

At the inaugural meeting of the first British Congress on the History of Medicine and Pharmacy, held in London on September 29, Sir Geoffrey Keynes and Prof. Owsei Temkin were awarded the honorary fellowship of the Faculty of the History of Medicine of the Worshipful Society of Apothecaries of London. The fellowship, which is an exclusive award to be held by no more than twelve at any one time, irrespective of nationality, is bestowed for outstanding services to scholarship in the history of medicine and pharmacy. Sir Geoffrey Keynes, whose work on Harvey, Sir Thomas Browne, John Ray and Robert Hooke is fundamental, is the first recipient of the new honour. Prof. Temkin, who is director of the Institute of the History of Medicine in Johns Hopkins University, Baltimore, has made many erudite studies of classical and medieval medicine, his authoritative monograph on "The Falling Sickness" being the most widely known of his works.

The Medical Research Council states that in future all requests for compounds in the Steroid Reference Collection should be addressed to Prof. W. Klyne, Chemistry Department, Westfield College, Hampstead, London, N.W.3, and not to the Postgraduate Medical School at Hammersmith.

Erratum. Dr. C. W. Beklemishev has written in connexion with his communication entitled "Southern Atmospheric Cyclones and the Whale Feeding Grounds in the Antarctic" in *Nature* of August 6, p. 530; his address should read: "Oceanological Institute, 8 Bahrushin Street, Moscow 127".

PHYSICS EDUCATION

"THE difference between agriculture and farming" (a percipient candidate recently observed in an Ordinary Level General Certificate of Education examination) "is that in farming you actually do it". The gulf separating the doers and the talkers is conspicuous in the field of education, but the teachers who attended the recent International Conference on Physics Education managed to illuminate several important problems with little help from the platitudes so often displayed on such occasions.

Eighty invited representatives from twenty-eight countries formed the membership of the conference, which met at Unesco House, Paris, during July 28–August 4, under the sponsorship of the United Nations Educational, Scientific and Cultural Organization, the Organization for European Economic Co-operation and the International Union of Pure and Applied Physics. Prof. Sanborn C. Brown of the Massachusetts Institute of Technology was in the chair, and Mr. Norman Clarke of the Institute of Physics was secretary of the conference.

The main topics on which discussion centred were : (*a*) the need for instruction in physics from an early age (seven years was proposed without dissent) ; (*b*) the inadequacy of present-day methods of teaching physics in European and North American schools ; (*c*) the difficulties found in trying to introduce Western educational ideas into Oriental countries ; and (*d*) the need for radical innovations, exemplified by the concurrent exhibition of new teaching aids and the fully documented account of the Physical Science Study Committee's work in the United States.

The proceedings opened with a vigorous iconoclasm, presented by a working party appointed to examine the teaching of physics in schools. It found that contemporary physics courses in most European countries involve no scientific knowledge that has been discovered during the past few decades. Generally they offer a number of so-called facts and laws, combined with simple but pointless experiments to form "a somewhat desiccated and often strongly mathematical course based upon a few elementary physical principles". The presentation of physics in schools was condemned for failing to exploit the natural curiosity of children about the world in which they live, or to recognize their present-day familiarity with outstanding examples of applied science.

Strong criticism was expressed of physics courses intended primarily for the instruction of future specialists and of the truncated fragments which are all that can be acquired by pupils who leave school at sixteen. It was agreed that physics should be taught to all pupils and that the needs of those who do not intend to specialize must predominate. Neglect of this requirement was blamed for the drift towards a world of two cultures with a false antithesis between sciences and humanities. Lack of time was not regarded as a justification for early specialization. On the contrary, it was insisted that future specialists would be all the better for an early course of a broader kind and that a couple of years after the age of sixteen should provide ample time for additional instruction to meet university entrance requirements.

Discussing the content of an ideal physics course, the conference affirmed the basic position of mechanics, but recommended that it should be taught as a science, with a constant appeal to Nature, and not allowed to degenerate into a branch of applied mathematics. The child's introduction to physics should be through a consideration of atoms, molecules and electrons, rather than by the customary study of mechanics and hydrostatics. Practical work, it was suggested, should become more realistic, though the changes needed cannot be defined without further investigation. The proportion of time spent on practical work done by the pupils (about half all the time devoted to physics) in many English schools was judged to be excessive, particularly since much of it involved merely the measurement of standard quantities by methods possibly of historical interest, but of no use to the practising physicist.

Having diagnosed the malady and prescribed the treatment, the conference acknowledged the shortage of teachers qualified to administer it. Low salaries were reported as a major discouragement in some countries, though improved scales did not always have any obvious effect on recruitment. Working conditions, opportunities for advancement, contact with other scientists and—perhaps most of all—social prestige were named as factors influencing the choice of a career among those who might be attracted to teaching.

European and American ideas on the teaching of physics in schools and universities have been adopted with varying degrees of success in other parts of the world. After the proclamation of the Turkish republic nearly forty years ago, many drastic reforms were accomplished in the desire to break away from the old philosophy and to embrace Western ideas. In this movement the encouragement of scientific studies was important both in aiding the country's industrial development and in promoting the attitude of mind favourable to the absorption of Western culture. Educational methods drawn from British and American experience are combined in the system now used successfully for the teaching of physics at school- and university-level in Turkey.

Japanese delegates told a different story. When their country first embraced Western civilization, nearly a century ago, physics was made a compulsory subject in high schools and retained this status until 1948. By then an educational mission from the United States had reported unfavourably on the exaggerated respect for authority inculcated by the prevailing system of teaching which, in physics, involved cramming from a text-book with little experimental work. Under the new dispensation, the study of physics in high schools was made optional and was promptly abandoned by two-thirds of the senior pupils. For several years the school curriculum included only one scienee subject, in which the university entrance examination was also taken. Many pupils offered biology—which they thought to be easily learned—even though intending to study physics or engineering at the university. Some universities, in defiance of the Ministry of Education, started their own entrance examinations in physics to ensure that students were adequately prepared.

Public opinion supporting this stand, the high school curriculum was modified in 1956 to include two science subjects, and the enrolment in physics has now increased from 33 per cent to 75 per cent. Nevertheless the present arrangements for teaching physics in Japanese schools were reported by Haruo Ootuka (Tokyo) to be "almost completely unsuccessful".

The Western traditions which form the basis of these experiments are themselves under close scrutiny in the United States, where the Physical Science Study Committee has spent 5,000,000 dollars since 1956 on the preparation of a radically new curriculum for high school physics. The Committee's syllabus, intended for a one-year course to pupils aged 15–17 years, discards much that has been familiar to teachers and students during the past half-century, offering instead a penetrating analysis of selected topics contributing to a logical picture of the universe. The student who follows the course will know little about hydrostatics, the tangent galvanometer or the compound pendulum—but he will have measured the thickness of a tissue by counting interference fringes, he will have studied the Franck–Hertz experiment on atomic energy-levels, and he will have a working knowledge of vector kinematics.

Text-books and laboratory guides are supplemented by a large collection of films, some still in preparation, and by a series of paper-backed books. Apparatus for experiment and demonstration is being manufactured at modest cost by an American scientific instrument firm.

More than 30,000 students have taken the course in its preliminary versions. A considerable expansion of the programme is expected when the literature and other teaching aids become available on a large scale towards the end of 1960.

Many ideas brought forward in the discussions were underlined in the exhibition of apparatus, arranged by G. R. Noakes (Uppingham). The United States, Britain and France provided most of the material on view, but interesting contributions came from a few other European countries. Manufacturers showed real ingenuity in devising simple apparatus for studying and illustrating the principles of contemporary physics.

Speaking in Brussels on April 27, Lord Hailsham asked: "Can we feel sure that, in evaluating the methods of science teaching now in use, and the possible way in which they might be improved, we are ourselves approaching the matter scientifically? Can we be sure that we are practising what we preach?" The International Conference on Physics Education has helped to answer this question. Further gatherings, perhaps with more limited objectives, would make a modest but distinctive contribution to the cause of education. J. M. A. Lenihan

SEVENTH CONGRESS OF THE INTERNATIONAL SOIL SCIENCE SOCIETY

THE seventh Congress of the International Soil Science Society was held at Madison, University of Wisconsin, under the presidentship of Prof. Richard Bradfield of Cornell University, during August 15–23, with the motto "Promote Peace and Health throughout the World by alleviating Hunger through Soil Science". In the seventh Congress, sixteen hundred delegates, representing more than fifty countries, assembled and discussed nearly four hundred original contributions on different aspects of soil science and soil improvement in seven commissions or divisions. Moreover, there were seven general lectures and one symposium on tropical soil resources under the Food and Agriculture Organization. In the opening session on August 15, the members of the Congress were welcomed by the Governor of Wisconsin and the president of the University, and addresses were delivered by the director-general of the Food and Agriculture Organization, Mr. B. R. Sen, Prof. Bradfield and Dr. C. E. Kellog, the vice-president of the Congress.

Three tours were organized in which the activities and achievements of the universities and Government Departments of the United States in agriculture and soil conservation were demonstrated. Numerous soil profiles in many parts of the country were intensively studied and photographed. Lysimeter tests were exhibited at the soil and water conservation research station at Coshocton, Ohio.

The chief topics for study and discussion at the Congress were: soil classification, cartography and maps of soils, soil physics, moisture retention, irrigation, fertility, structure, morphology, soil chemistry, analysis, diagnosis, organic matter, humus, composts, soil fauna and soil formation, micro-organisms, interaction of organic and inorganic matter in soils, clay minerals, genesis, the use of isotopes, liming, fertilization by nitrogen, phosphate, potash, trace elements, management of forest soil, saline soils, alkaline soils, etc.

Dr. F. E. Bear, a leader of soil science in the United States, in his report on "Soil in Relation to Nutritional Needs in Foods", stated that man can effect organic and mineral nutrient balance in his diet by taking a variety of plant products from many soils and meat, eggs and milk, but unfortunately such a selection is not always possible. Dr. G. D. Scarseth reported that the soils of humid tropics are highly leached and are poor, and when cleared for farming have to be adequately fertilized. According to Dr. K. H. Schütte and S. Amdurer, trace-element deficiency is widespread in South Africa. Dr. W. H. Allaway claimed that there is little evidence of harmful results from chemical fertilizers as envisaged by the late Dr. A. Carrel in his book "Man the Unknown".

In an important paper on the "Relation of Radioactive Contamination of Crops to Soil Fertility", Drs. R. F. Reitemeir and R. G. Menzel stated that the hazard associated with accumulation in the soil of the shorter-lived fission products, for example, iodine-131 and barium-140, is slight, but longer-lived isotopes like strontium-89, strontium-90 and cæsium-137 are more dangerous. Addition of large amounts of organic matter to soil reduces the uptake of radio strontium and calcium. Prof. E. Turog

described the development of soil testing methods in the United States during the past fifty years.

A large number of important communications on soil nitrogen, nitrification, nitrogen fixation, soil humus, composts, loss of nitrogen from soils, residual fertility, etc., were taken up in several sections of the Congress, because it is well established that nitrogen is the key element in cereal and other food production. Field trials in temperate countries show that one pound of nitrogen applied produces 16–17 lb. of cereals or other tillage crops, while in tropical countries the production is ten times the nitrogen input. This increase seems to be determined by the humus content in the soil; the soil humus is greater in cool countries than in the tropics. It has been estimated that approximately 1,000 million tons of grains, including corn and 700 million tons of other food materials, are produced in the world at present. This food production requires 100 million tons of combined nitrogen. But the chemical nitrogen industry is providing 7 million tons, legumes 5 million tons, precipitation about 5 million tons and farmyard manure about 2 million tons in world agriculture. In the United States 1·5–2 million tons of chemical nitrogen, 2 million tons of legume nitrogen and perhaps 1 million tons of farmyard manure nitrogen are applied, although approximately 15 million tons of nitrogen are taken out annually from the 510 million acres of agricultural lands. Hence even to-day the majority of the nitrogen need of world crops is being met by the soil nitrogen, which must be augmented in permanent agriculture. One of the easiest methods of increasing the soil nitrogen is to plough in straw after removal of grains, cornstalks, dung, grasses, legumes, etc., mixed with 50–100 lb. phosphate (as Thomas (basic) slag) per acre, as advocated by Prof. N. R. Dhar in the Congress and elsewhere. In this manner 100 lb. of atmospheric nitrogen can be fixed per acre of land and this method is applicable to both tropical and temperate countries, which require an interval of 100–150 days for adequate nitrogen fixation and liberation of available nitrogen, phosphate and potash for crop-growth in these lands. In this connexion, it is of interest to record that the British Association for the Advancement of Science meeting held in 1949 and presided over by Sir John Russell concluded that only 3 per cent of world food production could be attributed to artificial nitrogen. Moreover, as the application of phosphates increases the yield of crop to the extent of 5–7 times the amount of phosphorus incorporated in the soil, a very large number of papers on phosphorus availability, placement, etc., were considered at the congress.

In reaching Madison, Wisconsin, via Tour 1 and leaving Madison via Tours 2 and 3, the delegates passed through the heart of the Corn Belt, located in the twelve North Central States, which occupy the upper portion of the Mississippi Valley. The United States produces more than half the world's maize and soy beans, and approximately one-sixth of the wheat. The bulk of these is produced in the prairie soils rich in nitrogen and humus, obtained by the natural incorporation of tall grasses in the land and by absorption of sunlight at the surface soil. It seems that no other large area in the world equals these parts of the United States as regards favourable conditions of soils (prairie, chernozem and grey-brown podzolic) and climate for the production of crops. The State of Iowa is the main producing area for maize and pork, Illinois for soy beans, Wisconsin for hay and canning crops and dairy products, which form one-seventh of the milk and half the cheese produced in the United States. The legume alfalfa (lucerne) is the main hay crop and is extensively grown.

The representatives of soil science, from many countries, including the U.S.S.R., Japan, China, India, South Africa, Ghana, Sudan, Congo and all European nations, assembled in Madison, and carried on deliberations in a cordial and friendly atmosphere for creating new knowledge, leading to the progress and welfare of the common man in the world and contributed to international friendship, co-operation and stabilizing world peace. N. R. Dhar

SOIL SURVEY IN THE WEST INDIES

UNDER the general direction of Dr. T. A. Jones steady progress has been made with the soil survey work of the Regional Research Centre of the British Caribbean, which has its headquarters at the Imperial College of Tropical Agriculture in Trinidad. The first three monographs to appear, namely, "The Parish of St. Catherine, Jamaica", "The Rupununi Savannas of British Guiana", and "St. Vincent" were reviewed in *Nature*, **184**, 27 (1959). A further seven have now been published, covering another four of the parishes of Jamaica (St. Andrew, Clarendon, St. James and St. Mary), two further groups of selected areas in British Guiana and the island of Grenada (with Carriacou)*. Two other parishes of Jamaica are reported as completed, leaving six to be done. Each memoir follows the same plan, and as each is intended to be used as a self-contained guide there is a large amount of repetition. Each is divided into three parts: (1) Factors affecting land use (climate, geology and lithology, relief and drainage, the people and their agriculture, present position of services); (2) the soils and their capabilities; (3) recommendations. Each monograph has a soil map in a pocket and for Jamaica the scale of 1 : 50,000 has been adopted; for Grenada the rather strange scale of 1 : 18,750 has been used. The use of a series of tints and symbols in red over a black outline has enabled much detailed information to be shown on the maps with, doubtless, a minimum of expense.

Although called a "Soil and Land-Use Survey" the existing land use has not in fact been surveyed: throughout, the aim is the severely practical one of relating potential use to soils. It is interesting to note that this has led to the re-use of the older approach to soil study—the grouping of the soils according to parent geological material—since it is found that this has the closest bearing on potential. Soil series are named and used, but take a subordinate place. In fact, Dr. Jones has given his reasons

* Regional Research Centre of the British Caribbean at the Imperial College of Tropical Agriculture, Trinidad, W.I. Soil and Land-Use Surveys. Monographs 4–10. 1959–60.

elsewhere (*J. Soil Sci.*, **10**, 196; 1959) why the soil-profile should be abandoned as a basis of classification since soil is "essentially a part of the landscape".

It is almost inevitable, as well as desirable, that this sustained and intensive soil work in the tropics should give rise to serious heart-searching among soil scientists. At one extreme are those pedologists who contend that soils should be studied *quâ* soils, without any consideration for their economic use, and some who even consider only 'natural' soils should be mapped, and that those where pedogenic processes have been impeded by cultivation should be ignored. At the other end of the scale are those who urge that a soil map or a soil study has little value *per se*, unless related to the potential use of the land. At this end of the scale the extreme position is taken, as by Basil Furneaux, that there is little use in mapping at all and that the only useful approach is the *ad hoc* investigation of a soil in relation to its specific utilization. The West Indian work is nearing the latter approach, except that detailed mapping has been combined with full laboratory investigation. Each soil type which is mapped is given in tabular form a recommended cultivation practice. It is hoped the farmer will not be alarmed to find his land requires, for example, *PS*/3 *ND*/*VW*, which means contour ploughing in three strips, with two in cover but no drains though with vegetative barriers and stone walls. Next he is told what crops out of some 15 may be grown, and warned of special hazards, peculiarities and nutrient requirements.

Most of the West Indian islands have problems of severe population pressure on land resources, and here is a scientific approach to the solution. But how far will the recommendations be followed? How successful would they be? It is too much to hope that they will be applied experimentally over some considerable test areas? The proof of the pudding must be in the eating. L. Dudley Stamp

THE AUSTRALIAN ATOMIC ENERGY COMMISSION

STEADY progress is the keynote of the seventh annual report of the Australian Atomic Energy Commission. The report, which covers the financial year ended June 30, 1959, was presented to the Senate on March 10, 1960, by Senator W. H. Spooner, the Minister of State for National Development, who stated that earlier years had been years of innovation and trial as one new activity or another was begun in furtherance of the Commission's objectives, but, as the report shows, that phase had now been left behind*.

The report is divided into seven sections dealing respectively with the search for uranium; uranium mining; raw materials including beryllium and thorium; the research programme; prospects in Australia and overseas for nuclear power; international agencies and conferences; and general activities. The financial accounts and details of research contracts, postgraduate research studentships and undergraduate scholarships, in addition to a list of the Research Establishment buildings at Lucas Heights and of the members of the staff of the Commission, are given in six appendixes.

Air-borne surveys for uranium were on a smaller scale than in previous years, because of a shift in emphasis from uranium search to regional geological mapping, and a contraction of air-borne work in general. At Rum Jungle a detailed programme of geochemical testing was carried out to the west, north-west and south of the mine, and the area was systematically explored for additional ore. Five discoveries of radioactive minerals were reported to the Commission during the year, but none proved significant as possible sources of production.

The production figures given in the report for operations at Rum Jungle show that the uranium section of the plants proceeded satisfactorily, although the production of oxide was only about three-quarters of that during 1958 because of lower grade of head feed to the treatment plant. Two companies, the United Uranium N.L., and the South Alligator Uranium N.L., both operating in the South Alligator River area, concluded an arrangement with the United Kingdom Atomic Energy Authority for the sale of uranium oxide to the United Kingdom of a total value of approximately six million pounds. The United Uranium's contract, of approximately five million pounds, is for the delivery of oxide during May 1959 and December 1966, and the South Alligator Uranium's contract for the delivery of the remainder during August 1959 and early 1963.

The report comments on the fact that there is at present a world surplus in uranium and that the lull in demand foreseen for the decade 1960–70 sets problems for the Australian mining industry which is now in steady production and which has sufficient ore reserves to fulfil current contracts and to meet Australia's domestic requirements until about 1980. The Commission wishes to maintain an active mining industry in order that new reserves may be developed and to ensure that Australia's long-range needs may be met. It is therefore important that producers should secure overseas markets for their output during the late 'sixties, but in accordance with the Commonwealth Government's principles the exports must be strictly for peaceful purposes. The stockpiling of monazite was continued, but some relaxation on export was allowed. Export of beryllium ores and concentrates remained prohibited.

New buildings to provide additional permanent workshop and laboratory space at Lucas Heights were started during the year under review. These included a large metallurgy/engineering building, a special building for beryllium research, and another devoted to isotopes and technical physics. The reactor *Hifar* was taken up to full power, after two years of calibration and testing, and although the reactor is primarily a materials testing reactor, it has begun also production of radioisotopes for medical, scientific and industrial use. Australian industry is still hesitant in adopting radioisotope techniques, but some improvement was reported during the year. In the reactor physics section theoretical investigations were carried out with the aid of computers on the slowing down of neutrons in beryllium and graphite, and the variation with neutron energy of

* Commonwealth of Australia, 1959. (Sydney: Australian Atomic Energy Commission, 1960.)

absorption in thorium was studied in relation to conversion factor, that is, breeding uranium-233 fuel from thorium. The technical physics section provided additional safety instrumentation for *Hifar* and designed and constructed a wide variety of instruments for nucleonic and physical measurements. Generally, more emphasis was placed on the high-temperature gas-cooled reactor project than on the liquid metal cooled reactor system since it was shown that this system would require a longer period of development. Work on liquid metals was largely restricted to sodium technology required for *Hifar* irradiations. Optimum conditions for the vacuum hot-pressing of reduced beryllium powder and electrolytic powder were established, and laboratory-scale extrusion processes for beryllium metal were developed. Research on the impregnation of graphite with furfuryl alcohol to produce graphite of very low gas permeability was carried out, and a number of sample fuel elements of uranium and thorium dispersed in a diluent were prepared.

The number of staff at the Establishment rose from 295 to 484 during the year, but there was difficulty in recruiting research officers of the required ability and experimental officers. The Commission was represented at the inaugural meeting of the council of the Australian Institute of Nuclear Science and Engineering which was held on December 4, 1958, and at the Second International Conference on the Peaceful Uses of Atomic Energy in Geneva. The major publication during the year under review was "Australian Atomic Energy Symposium, 1958", the record of the proceedings of the symposium on the Peaceful Uses of Atomic Energy in Australia, held in Sydney during June 1958. Other publications included the booklet entitled "An Introduction to Nuclear Science", prepared at the request of the New South Wales Department of Education as a teaching aid in schools, and the quarterly journal *Atomic Energy*. A total of approximately £A.30,000 was provided for extra-mural research contracts to universities. Thirty-five separate research programmes were being undertaken in eight universities and two hospitals and except for a few which were held up by staffing difficulties they were making good progress. Several were nearing completion. No new undergraduate scholarships were awarded, but fifteen undergraduate students continued their training in addition to forty postgraduate research studentship holders.

PUBLIC OPINION POLLS IN JAPAN

PUBLIC opinion polls are an item of American culture which the Japanese have adopted since Hiroshima. "At the height of their popularity during 1946–50 polling agencies in Japan conducted surveys on everything from attitudes towards the Emperor, housing and daylight saving time, to telephone service, prostitution, school lunches and Typhoon 'Jane' ". Dr. Matsumoto, who is chief of the Department of Medical Sociology of the Atomic Bomb Casualty Commission, is very well aware of the limitations of this kind of democratized publicity, but he has had the interesting idea of investigating how far this widely ranging material displays a consistent pattern which is in contrast to the ethos of traditional Japanese society*. He considers four main fields of opinion : attitudes towards family and sex relationships, attitudes towards occupation and labour, attitudes towards village life, attitudes towards political leadership.

After a brief description of the orthodox values of the traditional society, Dr. Matsumoto gives the results of a large number of opinion surveys dealing with such questions as : Should an individual choose his own marriage partner or should the parents decide ? Do you feel that abortion should generally be permitted ? Is there a social necessity for organized prostitution ? Do you think the labour unions are protecting the interests of the workers ? How do you feel about the abdication of the present Emperor ? The book ends with an "Interpretation and Summary" which is sensible but not profound. It scarcely needed a study of this scale to discover that "Japan has been under strong pressure to conform to Western ideology in her post-war situation. On one hand individualistic orientations are heralded ; on the other communistic values are proclaimed". There is a good deal of such writing, but so long as Dr. Matsumoto evades the pressure to conform to the clichés of American sociology he is quite fascinating. The bibliography of Japanese sociological studies at the end of the book should be very useful to specialists. EDMUND LEACH

* Contemporary Japan : the Individual and the Group. By Yoshiharu Scott Matsumoto. Transactions of the American Philosophical Society. New Series, Vol. 50, Part 1. Pp. 75. (Philadelphia : American Philosophical Society, 1960.) 2 dollars.

MASS DENSITY NEAR THE SUN

IT has been known for many years that there is a close relation between the gravitational force of our Galaxy near, and perpendicular to, its plane, the distribution of stellar velocities and the density distribution of matter. The classical investigation of this subject was made by J. H. Oort in 1932, and a number of other investigations have been made since that time.

E. R. Hill has recently published (*Bull. Astron. Inst. Netherlands*, **15**, No. 494, 1 ; 1960) a comprehensive discussion and a new analysis of the available data. His work is based on stars of type *K* ; this type was chosen because *K*-type stars occur in relatively large numbers at high galactic latitudes and statistical data on their brightness and motions are much more complete than for other kinds of stars. The velocity distribution of the stars perpendicular to the galactic plane has been represented as the sum of three components, two of low velocity and one of high velocity. The distribution of velocities parallel to the plane was studied as a function of height above the galactic plane. The distribution of giant *K*-stars was derived from the observed distribution of all stars of type *K* by using the observed

total proper-motion distributions of K stars to assess the proportions of giants at various apparent magnitudes.

All this information was then combined to yield the force of attraction of the Galaxy perpendicular to its plane, in the solar neighbourhood, as a function of distance from the plane. Finally, the total density of matter in the plane of the Galaxy near the Sun was calculated. The result is $9{\cdot}2 \times 10^{-24}$ gm./cm.^{3}, or 0·13 solar mass per cubic parsec. This is somewhat larger than obtained by Oort in 1932.

Hill's work suffers from the disadvantage that for distances of more than 500 parsecs from the galactic plane the force obtained conflicts with the requirements of Poisson's law.

In another paper, J. H. Oort (*Bull. Astron. Inst Netherlands*, **15**, No. 494, 45; 1960) re-determines the force so that it is consistent both with the observational data assembled by Hill and with Poisson's law. He obtains 0·15 solar mass per cubic parsec for the density of matter in the solar neighbourhood, in excellent agreement with the result of Hill.

DWARF MISTLETOES

A COMPREHENSIVE account of morphological aspects of the parasitism of dwarf mistletoes (*Arceuthobium* spp., Loranthaceae) on North American conifer species has been given by J. Knight (*Univ. California Pub. Bot.*, **30**, No. 5, 337; 1960). Some of the literature, terminology and main features of the development of these parasitic plants are critically reviewed and new observations submitted relating to *A. americana* and other species. At the time of penetration into the host the radicular apex loses its histological organization and becomes resolved into simple uniseriate filaments. Such filaments eventually become vascularized endophytic strands. It is possible that all radial sinkers and some aerial shoots may take their origin directly from uniseriate filaments.

All species of *Arceuthobium* may at maturity show a localized distribution pattern of the endophytic system and shoot emergence from the host. Such infections are in some cases associated with brooming phenomena of the tree. In addition, some species when infecting certain hosts induce a remarkable brooming response where the endophytic system keeps up with longitudinal host extension and where a great regularity of shoot emergence prevails. This is described as 'isophasic' parasitism.

There are recognizable differences in isophasic behaviour among species in which it occurs. These differences involve the position of mistletoe shoots in relation to host organs, dominance and precociousness of mistletoe shoots at the girdles, duration of reproductive activity, and so on. A mistletoe species causing an isophasic response on one host species may not do so on another; similarly, a tree when infected by one mistletoe may form an isophasic broom, whereas infection by a second species may result in an entirely different type of parasitism. The isophasic capacity does not therefore reside solely in either host or parasite, but is the result of mutual interaction. The endophytic system is most extensively developed in isophasic brooms. In those of *A. americana* on *Pinus contorta* and of *A. douglasii* on *Pseudotsuga menziesii*, the ultimate filaments are present in the apical meristems of the host branches and probably remain there throughout the yearly growth-cycle. In the latter broom, an actual emergence of endophytic filaments takes place just above the youngest bud scales. The author suggests that the endophyte may be present in the apical meristem of the host branches of all isophasic brooms, and that such presence in the host apex is a corollary of regularity in shoot emergence.

FACT AND FICTION ON THE BREEDING OF THE WANDERING ALBATROSS

By Dr. R. CARRICK, K. KEITH and Dr. A. M. GWYNN

Wildlife Section, Commonwealth Scientific and Industrial Research Organization, Canberra, and Australian National Antarctic Research Expeditions, Melbourne

THE reputation of the wandering albatross (*Diomedea exulans*) as a parent has suffered on occasion at the hands of the ornithologist, professional and amateur alike. The starvation theory held that the young albatross was fed from hatching in March until about June, and then deserted throughout the Antarctic winter while it subsisted on reserves of stored fat. Some writers state or imply that there is no resumption of parental feeding before the fledgling takes wing about December; others cite observations of feeding, or of fresh food in the nestling's stomach, in spring. The relevant evidence and opinions of successive writers are:

1865. Hutton[1] stated that Harris at Kerguelen saw no adults between June and October, and no feeding from October onwards.

1866. Andersson[2] quoted the opinion of a sealer that young albatrosses live on their own fat after being abandoned by the parents.

1891. Chapman[3] stated that Fairchild observed albatrosses, nearly all young, on the islands below New Zealand in October, 1890, and concluded that the large full-grown chicks are abandoned and live on their own fat until they fly.

1905. Buller[4] quoted Buckland, who visited islands to the south of New Zealand, to the effect that the

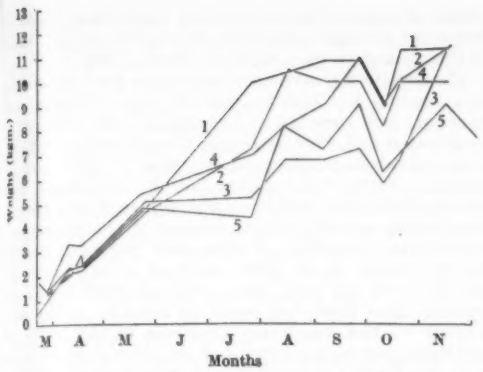


Fig. 1. Growth curves of five young wandering albatrosses at Macquarie Island during 1956

nestling becomes so fat that it exceeds the full-grown adult in weight, and is then deserted for at least four months until October.

1929. Matthews[5] spent the winter of 1925 at South Georgia and identified Nototheniid fish in the stomachs of young wandering albatrosses in early September; at that time the parents return about once a day and remain only a few minutes to feed the nestling. From observations in November and December 1925 and January 1926, Matthews concluded: "The adult albatross do not breed every year, as they do not finish feeding their young until after the new season's eggs are laid (by other birds) and incubation has started. Consequently there must be an interval of at least one season between the consecutive matings of any one bird".

1936. Murphy[6], who visited South Georgia during December 1912–February 1913, stated: "With the setting in of the antarctic autumn, the adult albatrosses completely abandon their nestling offspring, not for a matter of days or weeks but forever". (An extravagant misstatement in view of Matthews's evidence.) He found several young with empty stomachs shortly before they were due to fledge.

1951. Rankin[7] observed a breeding colony at Albatross Island, South Georgia, during December 1946–March 1947. On the assumption that the rate of increase in weight at the end of March would be maintained, nestling weight at the end of June was estimated at about 27–31 lb., and considered to be "far in excess of that of the adult"; the heaviest adult male weighed was 26¼ lb., and the average of fourteen adults was [illegible]. He concluded that "by finishing with their family cares in June or July, the parents have a clear four or five months before the beginning of the next breeding season, so it is possible for them to reproduce every year". His caption of Fig. 42 is: "Throughout the long Antarctic winter the young albatross is tended by its parents".

1951. Matthews[8] re-stated his previous evidence and conclusions, referred to "a year of devoted care" by the parents, and stated "at most they can breed only every other year".

1952. Richdale[9] fully reviewed winter feeding of young wandering and royal (*D. epomophora*) albatrosses, establishing beyond doubt that it occurs in the latter species, and quoting Turbott's observation of wandering albatross chicks being fed early in November 1950 at Antipodes Island.

1953. Paulian[10] observed and photographed feeding at Kerguelen during August and September.

1954. Fisher and Lockley[11] discussed the starvation period of nestling Procellariiformes, and agreed with Richdale[9] that *D. exulans* has little, if any.

1958. Jameson[12] stated: "*Facts* about the all-important period from May to November—the Antarctic winter and spring—are lacking". ". . . but I believe, with Matthews, Murphy and Rankin, that the young are abandoned for several months" (not at all fair to Matthews). Jameson does not refer to Paulian[10].

1960. Tickell[13] studied the wandering albatross at Bird Island, South Georgia, during October 1958–March 1959. In November–December "nestlings being handled frequently regurgitated large fresh meals and the sight of the adults feeding young was fairly common". Despite the evidence[5,8,9,10,13] for feeding of chicks every month from August onwards, Tickell computed a hypothetical weight which the nestling would have to attain by July in order to fledge at the December weight without further feeding. This is based on the physiologically dubious assumption that the unfed downy chick during winter might lose weight at the same rate as the large feathered chick in summer. He concluded that "the evidence now available clearly indicates that the young are fed throughout the fledgling period".

By 1953, if not by 1929, the starvation hypothesis had become untenable, on five counts. Matthews[5], Turbott (in Richdale[9]) and Paulian[10] had published evidence of feeding during August–December. Richdale's[9] detailed and accurate study of the royal albatross, and the well-known life-history of the king penguin (*Aptenodytes patagonica*), had shown that the other two sub-Antarctic sea-birds, the young of which develop throughout winter, do not neglect them. The energy requirements of a non-hibernating and growing bird, in this cold environment, must be very considerable indeed, and necessitate regular replenishment. Hormonal control of the annual cycle in birds precludes suspension of parental feeding behaviour for a lengthy period; a break with the proximate stimuli involved causes birds either to

Fig. 2. Adult male wandering albatross (C.S.I.R.O. band number 140–00149; colour-bands red-orange) feeding its own chick at nest No. 2, Macquarie Island, on July 26, 1956

revert to the onset of breeding or to proceed to the next phase, usually the moult. Ornithology offers no precedent for temporary cessation of parental care; so novel a suggestion requires undeniable proof.

Throughout 1956 Keith (biologist, Australian National Antarctic Research Expeditions) kept records of the development of wandering albatross nestlings at Macquarie Island. The five growth-curves (Fig. 1) show the increase in weight during winter; and Fig. 2 shows a young albatross being fed on July 26.

Tickell[13] also discussed whether adults feed their own or random chicks, a point on which there can be no doubt if the birds are marked. In view of the mounting evidence on this subject, of which only Sladen's[14] study of the Adelie penguin (*Pygoscelis adeliae*), the young of which form crèches, need be mentioned in addition to Richdale's[9] proof in the case of the royal albatross, it would be surprising indeed if the original parent-nestling bond were not maintained. Many observations of banded birds at Macquarie Island confirm that wandering albatross parents feed only their own young, but nests there are much more widely spaced than at Bird Island. Tickell's[13] final conclusion, "... it must be held that the wandering albatross, like the royal albatross, breeds only once every two years", also requires birds, the identity, and history during several years, of which are known. Matthews's[5,8] conclusion (quoted above) on similar evidence is more carefully correct. Since 1954, 48 adults and 37 young have been banded on Macquarie Island; frequency of breeding follows the pattern established by Richdale[9] in the royal albatross, namely that successful pairs breed in alternate years and early nest failures enable the next attempt to be made the following summer. Constancy of site and mate is the rule. The full results of the Macquarie Island studies are included in an Australian National Antarctic Research Expeditions report on the birds of this Island to be completed during 1961.

The wandering albatross is a noble bird which has long excited the imagination of poet, voyager and scientist, but canards ill become it. In 1929, after spending a full year at South Georgia and studying large wandering albatross colonies at the end of August, September, November to January, and March, Matthews[5] produced the evidence and correct conclusions on both winter feeding of the young and non-annual breeding of successful parents. Subsequent writers up to 1960, after at most a summer contact with the bird, have done his work less than justice. The time has come to consign much past writing on the wandering albatross to the limbo of ornithological mythology, and to replace speculation with the direct evidence, based on individual identification whenever possible, which modern ornithology demands.

1 Hutton, F. W., *Ibis*, **1**, 276 (1865).
2 Andersson, C. J., *Ibis*, **2**, 324 (1866).
3 Chapman, F. R., *Trans. N.Z. Inst.*, **23**, 491 (1891).
4 Buller, W. L., "Supplement to the Birds of New Zealand" (London, 1905).
5 Matthews, L. H., "Birds of South Georgia", *Discovery* Reports, **1**, 563 (1929).
6 Murphy, R. C., "Oceanic Birds of South America", 561 (Amer. Mus. Nat. Hist., New York, 1936).
7 Rankin, N., "Antarctic Isle" (Collins, London, 1951).
8 Matthews, L. H., "Wandering Albatross" (Macgibbon and Kee, London, 1951).
9 Richdale, L. E., "Post-Egg Period in Albatrosses" (Dunedin, New Zealand, 1952).
10 Paulian, P., "Pinnipèdes, Cétaces, Oiseaux des Iles Kerguelen et Amsterdam", *Mem. de l'Inst. Sci. de Madagascar*, A, **8** (1953).
11 Fisher, J., and Lockley, R. M., "Sea-Birds" (Collins, London, 1954).
12 Jameson, W., "Wandering Albatross" (Hart-Davis, London, 1958).
13 Tickell, W. L. N., *Nature*, **185**, 116 (1960).
14 Sladen, W. J. L., "The Pygoscelid Penguins", F.I.D. Scientific Report No. 17 (1958).

CHEMISTRY OF VISUAL ADAPTATION IN THE RAT

By JOHN E. DOWLING

Biological Laboratories, Harvard University, Cambridge, Mass.

Rhodopsin Concentration and Visual Sensitivity

THE loss of visual sensitivity after light adaptation, and the recovery of sensitivity during dark adaptation, are common phenomena. Hecht was the first to emphasize the idea that these processes represent the bleaching and synthesis of visual pigment. However, until very recently, experimental attempts to formulate the relationship between visual pigment concentration and visual sensitivity or threshold have not been fruitful, principally because in man, in whom visual thresholds are most commonly determined, pigment concentrations cannot easily be measured. In experimental animals, on the other hand, pigment concentrations can readily be measured, but special means must be employed to estimate visual thresholds.

Recently, in a study of vitamin A deficiency in rats[1], I used the electroretinogram to assay retinal function and sensitivity. I found that the electroretinogram threshold of the eye rose regularly and linearly with time on the deficient diet, similar to the rise of psychophysical thresholds in studies of human vitamin A deficiency[2]. When the measurements of electroretinogram threshold in the deficient rats were compared with the rhodopsin concentrations in the retinas of the same animals, it was found that the logarithm of the electroretinogram threshold rose linearly with fall in rhodopsin concentration.

I have now extended this analysis to light and dark adaptation. That one can use the electroretinogram to reflect the sensitivity of the eye has been demonstrated by several workers[3,4]. The most familiar way to do this is to evaluate the change of the electroretinogram during dark adaptation on the basis of stimulus response curves, so estimating the light intensities needed to elicit constant electroretinogram responses. I achieved essentially the same result by measuring, at various times during dark adaptation, the brightness of stimulus needed to evoke a just-perceptible electroretinogram. The electroretinogram threshold is perhaps preferable to measuring larger, super-threshold responses, which may be complicated by complex and changing waveforms.

The experiments were performed in the following way. Groups of animals were light-adapted for 30 min. in a white porcelain pan, brightly illuminated with three 100-watt flood lamps. At selected times after the lights were turned out, an animal was selected at random and the electroretinogram threshold recorded. Each measurement was made with a fresh animal, anæsthetized with nembutal (10–15 mgm.) 5–10 min. beforehand. To prepare for the first measurement (at 3 min.), anæsthetic was given to one animal a few minutes before the end of light adaptation. After an animal was anæsthetized, it could be prepared for the experiment and its threshold determined in about 3 min. Then the electroretinogram was recorded over a luminance-range of 5 log units.

The stimulus was a 1/50 sec. flash of white light, the luminance of which could be varied continuously with circular photographic wedges. The electroretinogram was recorded from the cornea with cotton wick electrodes connected with a Grass *P*-6 amplifier and Dumont oscilloscope fitted with a camera attachment. Capacity-coupled amplification was used to yield a more stable base line.

To measure rhodopsin, the same or other groups of animals were light-adapted as before on the following day. At appropriate times, an animal was anæsthetized, its eyes removed, and the retinas dissected free and dropped into cold 4 per cent alum solution. The retinas were collected pair by pair in this manner throughout the entire experiment. Each pair of retinas was finally washed twice with water, once again in neutral phosphate buffer, and the rhodopsin was extracted overnight with 0·2 ml. of 2 per cent digitonin. The next day, the extract was centrifuged clear, 0·01 ml. of 1 *M* hydroxylamine was added, and the absorption spectrum was run in a Cary recording spectrophotometer. The solution was bleached with white light for 5 min., and the absorption spectrum re-run. The difference in extinction at 500 mμ before and after bleaching indicated the concentration of rhodopsin. Measurements of rhodopsin in rats during dark adaptation have previously been made by Tansley[5] and Lewis[6]. In all, six complete experiments were performed measuring electroretinogram thresholds, and three complete experiments measuring rhodopsin concentration.

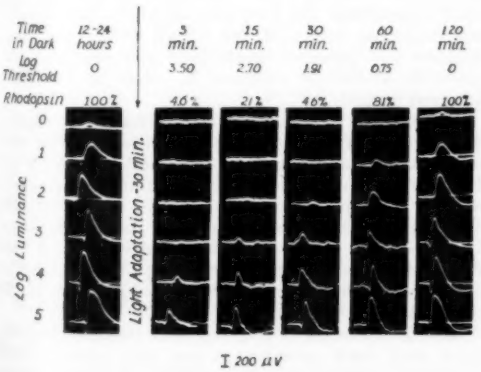


Fig. 1. Electroretinogram responses during dark adaptation in the rat. The top three lines show the time in the dark; the logarithm of the electroretinogram threshold, the lowest luminance necessary to evoke a perceptible electroretinogram; and the rhodopsin content expressed as percentage of the dark-adapted level. The electroretinograms are evoked with 1/50 sec. flashes of white light over a luminance range of 5 log units. The first row of electroretinograms shows the responses of a control animal, dark-adapted overnight. After light adaptation, the electroretinogram threshold is raised about 3·5 log units, and the responses at high luminances are diminished in size. With time in the dark, the threshold returns to normal, and the responses at higher luminances assume the dark-adapted form

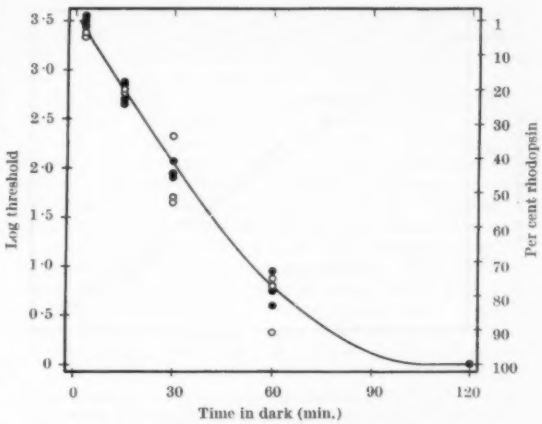


Fig. 2. Dark adaptation in the rat. Following light adaptation, the fall of the logarithm of the electroretinogram threshold parallels the rise in concentration of rhodopsin. Both the threshold and rhodopsin concentration are back to the dark-adapted level in about 100 min. ●, log threshold; ○, rhodopsin

Fig. 1 shows the electroretinogram responses recorded in such an experiment over a range of luminances of 5 log units. At the top of Fig. 1 the time in the dark following light adaptation is shown, and on the next line the logarithm of the electroretinogram threshold, the lowest luminance of light which evoked a perceptible electroretinogram. The normal threshold is set arbitrarily at 1, so that log threshold is 0. The third line shows the rhodopsin content, expressed as percentage of the completely dark adapted level.

The first row of electroretinograms shows the responses of a control animal which had been dark adapted overnight. After 30 min. of light adaptation, the threshold recorded after 3 min. in the dark was raised 3·50 log units (about 3,000 times). The rhodopsin concentration was reduced to 4–5 per cent of the dark-adapted level. With time in the dark, the sensitivity of the eye returned gradually to the dark-adapted state, in parallel with the rhodopsin concentration. Dark adaptation was completed in about 100 min.

Fig. 2 compares the rise in rhodopsin concentration and fall of electroretinogram threshold during dark adaptation. It is seen that the log threshold falls in strict parallelism with the rise in rhodopsin concentration.

Fig. 3 compares the relationship between rhodopsin concentration and log threshold both during dark adaptation and night blindness owing to vitamin A deficiency. It is clear that the logarithm of the electroretinogram threshold, even under these different conditions, rises and falls linearly with the concentration of rhodopsin. This relationship is expressed by the equation:

$$\log I_t/I_0 = 3{\cdot}6\ (R_0 - R_t)/R_0$$

in which I_0 and R_0 are, respectively, the threshold and rhodopsin concentration in dark-adapted control

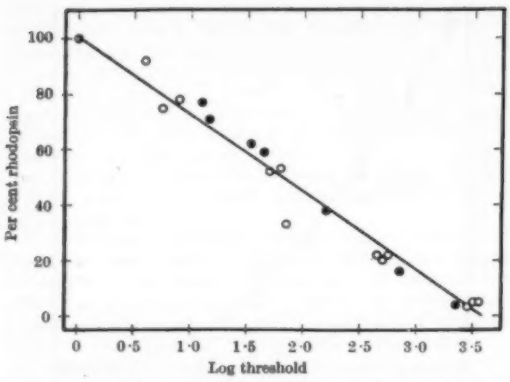


Fig. 3. The relation between rhodopsin content of the retina and the visual threshold in animals dark-adapted after exposure to bright light, and in animals night-blind due to vitamin A deficiency. In both instances, the same relationship is observed: the log threshold rises linearly with fall in rhodopsin concentration ●, Night blindness; ○, dark adaptation

animals, and I_t and R_t are, respectively, the threshold and rhodopsin concentration in vitamin A-deficient or partly dark-adapted animals.

This result is not wholly unexpected. Wald has pointed out the striking qualitative similarity between the synthesis of chicken iodopsin and rhodopsin in solution, and the course of human cone and rod dark adaptation[7]. This comparison is valid only provided that one compares the logarithm of the visual threshold with the concentration of visual pigment. Wald has also offered a theory which may explain such a relation[8].

Recently, Rushton *et al.* have made direct measurements of the rise and fall of human visual pigments in the living human eye during light and dark adaptation[9,10], and these measurements show a striking parallelism between the course of human light and dark adaptation, and the course of bleaching and re-synthesis of the visual pigments. Again, this relationship is evident only when the logarithm of the visual threshold is compared with the concentration of visual pigment[11].

Very recently, Rushton has compared the regeneration of rhodopsin and the course of dark adaptation under the same conditions in a colour-blind subject, and has also found that the logarithm of the threshold falls in parallel with the increase of rhodopsin content in the eye[12].

There have been several previous attempts to correlate the electroretinogram with visual pigment concentration[13–15], all of which have attempted to correlate the increase of visual pigment concentration with the increase in size of the *b*-wave potential elicited with a constant test-flash. As Riggs has pointed out, no simple proportionality exists between magnitude of electroretinogram response and the logarithm of stimulus intensity in the vertebrate eye[3]. Furthermore, the shape of curve obtained by plotting magnitude of response against time in the dark for intensity of a single flash may vary with the luminance of the test-flash selected[16]. As can be seen from Fig. 1, if the test light is too dim, one does not begin to record an electroretinogram until considerable quantities of rhodopsin have accumulated in the retina. This may explain why Granit, Munsterhjelm and Zewi failed to record an electroretinogram in the cat until 40 per cent of the visual pigment had been regenerated[14]. In the rat, as we have seen (Fig. 1), one can record an electroretinogram at any concentration of rhodopsin provided that the test stimulus is bright enough.

On the other hand, if the test stimulus were very bright, large fluctuations in rhodopsin might occur with little effect on the size of the electroretinogram potential. A preferable procedure on all counts is to evaluate the sensitivity of the eye by measuring the light intensities required to evoke a constant potential, perhaps most simply as here the just perceptible electroretinogram.

In summary, following 30 min. of intense light adaptation, the rhodopsin concentration of the eye of the rat is lowered to less than 5 per cent of the dark-adapted level, and the electroretinogram threshold has risen about 3·50 log units (about 3,000 times). With time in the dark, the logarithm of the electroretinogram threshold falls in strict parallelism with the rise of rhodopsin concentration. Both log threshold and rhodopsin content of the eye return to the dark-adapted level in about 100 min.

Distribution of Retinene and Vitamin A in the Eye during Light and Dark Adaptation

On exposure to light, rhodopsin bleaches to a mixture of retinene (vitamin A aldehyde) and the protein, opsin. The retinene may then recombine with opsin, forming rhodopsin again, or it may be reduced to vitamin A. After an intense and prolonged light adaptation, almost all the retinene in the eye is transformed to vitamin A[17].

Several years ago, Wald observed in frogs that the bulk of the vitamin A formed after light adaptation disappears from the retina[17]. More recently it has been shown that the total amount of retinene and vitamin A in the frog's eye does not vary during light and dark adaptation[18]; thus it seemed probable that exchanges of vitamin A occur between the visual cells and the pigmented layers (pigment epithelium and choroid) that lie in contact with them. Probably most, if not all, of these exchanges involve the pigment epithelium, the long processes of which envelop the outer segments of the visual cells. In many animals the pigment epithelium also contains considerable stores of vitamin A, even in the dark-adapted state[17].

Histological evidence for the exchange of vitamin A between retina and pigment epithelium has been obtained by Jancsó and Jancsó[19] and Greenberg and Popper[20], who observed typical vitamin A fluorescence in the pigment epithelium of the rat after light adaptation, which disappeared on dark adaptation. In agreement with the latter observations, I have found that the pigment epithelium of the albino rat contains no detectable stores of vitamin A in the dark-adapted state.

The distribution of retinene and vitamin A during light and dark adaptation has not hitherto been studied quantitatively. The albino rat seemed ideally suited for this purpose, both because in this animal the pigment epithelium contains no vitamin A when dark adapted, and because (unlike the frog) the retina readily separates from the back of the eye in either the light- or dark-adapted condition.

For these experiments, groups of animals (weighing 150–200 gm.) were dark adapted overnight, and then brightly light adapted in a white porcelain pan illuminated with three 100-watt flood lamps. For

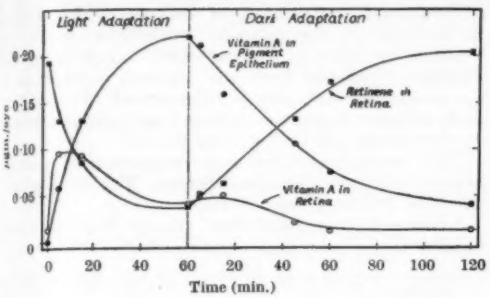


Fig. 4. Distribution of retinene and vitamin A in the eye during light- and dark-adaptation. During light adaptation, the retinene content of the eye falls, as the retinene, liberated on bleaching of rhodopsin, is reduced to vitamin A. Vitamin A in the retina rises for a time, and then declines, while the bulk of the vitamin A moves into the pigment layers. During dark adaptation, these processes are reversed. The retinene content of the eye increases, as rhodopsin is re-formed; and reciprocally the vitamin A in the pigment layers and retina declines. Dark adaptation is completed in about 100–120 min.

dark adaptation, the animals were placed in a small darkroom. At selected times during light- or dark-adaptation, the animals were anæsthetized with nembutal (15 mgm.), their eyes enucleated, and the retinas and pigment layers dissected apart, and placed separately in small mortars. (Throughout this article I shall refer to the back of the eye (pigment epithelium, choroid and sclera) as the pigment layers, even though there is no pigment in these tissues in the albino rat.) For each measurement, three animals (six eyes) were used.

The tissues were dried by grinding with a small amount of sodium sulphate, and the resulting powder transferred to a test-tube and extracted by vigorous stirring in 3 ml. of chloroform. After centrifugation, the clear chloroform extract (2·2–2·4 ml.) was drawn off, evaporated to dryness, and 0·3 ml. of fresh chloroform added. The amount of vitamin A and retinene in the extracts was determined by the Carr–Price reaction. For this, 0·25 ml. of the chloroform extract was mixed with 0·5 ml. of saturated antimony trichloride solution and the absorption spectrum from 700 to 500 mμ run immediately in the Cary recording spectrophotometer. Retinene absorbs maximally at 664 mμ, and vitamin A absorbs maximally at 620 mμ. When mixed, the amounts of vitamin A and retinene can be calculated by means of simultaneous equations[21].

Fig. 4 shows the results. It is convenient to express these in terms of the total potential vitamin A content of the eye; that is, vitamin A plus retinene, free and bound.

In completely dark-adapted animals, about 95 per cent of this potential vitamin A is bound as retinene in rhodopsin. About 5 per cent is stored as vitamin A in the retina. No vitamin A is found in the pigment layers.

On exposure to bright light, rhodopsin is bleached, liberating retinene. The retinene content of the retina, however, rapidly falls, as the released retinene is reduced to vitamin A. Reciprocally, the retinal vitamin A increases, and almost immediately vitamin A appears in the pigment layers.

With further time in the light the retinene content of the retina continues to fall, and after 30 min. reaches a level 10–15 per cent of the total potential vitamin A content of the eye. The retinal vitamin A, on the other hand, increases during the first 10 min. of light adaptation to a maximal level representing about 30 per cent of the total, and then gradually declines. After 45–60 min., it forms plateaux at a level of 10–12 per cent of the total.

The vitamin A in the pigment layers increases throughout the period of light adaptation. After 60 min., 75–80 per cent of the ocular vitamin A is found here. Retinene is never found in the pigment layers; the reduction of retinene to vitamin A takes place solely in the retina, and it is only vitamin A that migrates from the retina into the pigment layers.

It appears from Fig. 4 that there is more vitamin A present in the pigment epithelium after 1 hr. of light adaptation than there is total vitamin A (including retinene) in the eye to begin with. This is probably not the case; this artefact seems caused by my method of extraction, which removes vitamin A more efficiently than retinene. With equal amounts of vitamin A and retinene in a tissue, I extract only about 85 per cent as much retinene as vitamin A. This discrepancy could readily be corrected in the figure, but the raw data as they stand seem explicit enough.

During dark adaptation, these processes are reversed. The retina recaptures vitamin A by binding it as retinene in rhodopsin. The increase in retinene concentration during dark adaptation closely parallels the measured increase of rhodopsin concentration (compare Figs. 2 and 4).

With this increase of retinene, there is a reciprocal fall of vitamin A concentration in the pigment layers. The retinal vitamin A, on the other hand, stays relatively constant during the early stages of dark adaptation, and then gradually declines to its dark-adapted level of 4–5 per cent of the total vitamin A.

Dark adaptation is completed in about 100–120 min. I find at this time, however, a small amount of vitamin A in the pigment layers, which gradually disappears over the next few hours. During this time there is no increase of retinene or retinal vitamin A, so presumably this bit of vitamin A diffuses away into the blood stream. The origin and significance of this superfluous vitamin A is obscure.

Vitamin A in both the eye and body may exist in two forms: it circulates in the plasma as the free alcohol, but it is stored in the tissues primarily as the ester. It has been suggested that the vitamin A alcohol of the tissues is in equilibrium with that of the blood, and that through esterification a tissue can concentrate vitamin A independently of this equilibrium[22]. Krinsky has demonstrated the esterification of vitamin A in the eye tissues of cattle, and has found that much of the vitamin A, both in the retina and in the pigment epithelium, is esterified[23].

It is of interest to inquire as to the state of vitamin A in the pigment layers of the rat after 60 min. of light adaptation. For this, six animals were light adapted for 1 hr., their eyes enucleated, dissected, and the pigment layers extracted for vitamin A, as described above. The ester and alcohol fractions were separated on a column of alumina 'weakened' with 5 per cent water. Esterified vitamin A is eluted from such a column with 4 per cent acetone in petroleum ether, while free vitamin A is eluted with 20 per cent acetone in petroleum ether[24]. The fractions were assayed for vitamin A by the Carr–Price reaction. In two experiments, it was found that 92 per cent of the vitamin A in the pigment epithelium after 60 min. of light adaptation was esterified. Krinsky found that in cattle 87 per cent of the vitamin A in the pigment epithelium was esterified[23].

Vitamin A exists in the tissues in several geometric configurations, *cis-trans* isomers of one another[25]. The bleaching and synthesis of rhodopsin involves a cycle of stereo-isomerization: rhodopsin is synthesized from 11-*cis* (neo-*b*) retinene, and on bleaching releases all-*trans* retinene[25].

11-*cis* Vitamin A has not been identified in any tissue of the body, except in the eye[26]. There Krinsky has found that up to 65 per cent of the vitamin A in the pigment epithelium may be 11-*cis*[23]. It is of interest to inquire what isomer of vitamin A is found in the pigment epithelium after prolonged light adaptation. With this in view, the vitamin A was extracted from the pigment layers of six light-adapted animals as described above. The content of 11-*cis* vitamin A was determined by isomerizing with light in the presence of iodine, according to the method of Wald and Brown[27]. In two such experiments, no 11-*cis* vitamin A was detected.

There is considerable evidence, however, that in some animals the pigment epithelium does isomerize vitamin A[18,23,28], and it seems reasonable that vitamin A while in the pigment epithelium of the rat might undergo isomerization. Recently, Hubbard and Colman have shown that the amount of 11-*cis* vitamin A in the eye of the frog remains relatively low during the course of dark adaptation. Then, when the retina has ceased to remove it to form rhodopsin, the amount of 11-*cis* vitamin A in the eye increases 2–3 fold[18]. It seemed, therefore, that my failure to detect 11-*cis* vitamin A might be due to insufficient time for detectable quantities of 11-*cis* vitamin A to accumulate. I have tested this thesis in preliminary experiments by incubating the backs of light-adapted rat eyes in phosphate buffer for periods up to 4 hr., but have not as yet been successful in demonstrating the production of 11-*cis* vitamin A.

In summary, most of the vitamin A formed from retinene during light adaptation rapidly moves into the pigment epithelium. After 60 min. of light adaptation, 75–80 per cent of the total ocular vitamin A is found in the pigment epithelium, mainly as vitamin A ester. During dark adaptation, the vitamin A returns from the pigment epithelium to the retina as rhodopsin is regenerated. In the fully dark-adapted state, the pigment epithelium contains no detectable amount of vitamin A.

This investigation has been supported in part by grants from the National Science Foundation and the U.S. Public Health Service.

I should like to thank Prof. George Wald for many helpful discussions and suggestions.

[1] Dowling, J. E., and Wald, G., *Proc. U.S. Nat. Acad. Sci.*, **44**, 648 (1958).
[2] Wald, G., Jeghers, H., and Arminio, J., *Amer. J. Physiol.*, **123**, 732 (1938).
[3] Riggs, L. A., *J. Cell. Comp. Physiol.*, **9**, 491 (1937).
[4] Best, W., and Bohnen, K., *Documenta Ophthal.*, Sep. x, 351 (1956).
[5] Tansley, K., *J. Physiol.*, **71**, 442 (1931).
[6] Lewis, D. M., *J. Physiol.*, **136**, 624 (1956).
[7] Wald, G., Brown, P. K., and Smith, P. H., *J. Gen. Physiol.*, **38**, 623 (1955).
[8] Wald, G., *Science*, **119**, 887 (1954).
[9] Campbell, F. W., and Rushton, W. A. H., *J. Physiol.*, **130**, 131 (1955).
[10] Rushton, W. A. H., *Nature*, **179**, 571 (1957).
[11] Wald, G., Proc. Nat. Physical Lab. Symp., No. 8, Visual Problems of Colour (H.M.S.O., 1959).
[12] Rushton, W. A. H., Symposium on Life and Light, McCollum-Pratt Institute, Johns Hopkins University (in the press).
[13] Charpentier, G., *Acta Ophthal.*, Kbh. Supp. 9 (1936).
[14] Granit, R., Munsterhjelm, A., and Zewi, M., *J. Physiol.*, **96**, 31 (1939).
[15] Elemus, V., and Heck, J., *Nature*, **180**, 810 (1957).
[16] Johnson, E. P., and Riggs, L. A., *J. Exp. Psychol.*, **41**, 139 (1951).
[17] Wald, G., *J. Gen. Physiol.*, **19**, 351 (1935–36).
[18] Hubbard, R., and Colman, A. D., *Science*, **130**, 977 (1959).
[19] Jancsó, N. von, and Jancsó, H. von, *Biochem. Z.*, **287**, 289 (1936).
[20] Greenberg, R., and Popper, H., *Amer. J. Physiol.*, **134**, 114 (1941).
[21] Krinsky, N. I. (unpublished observations).
[22] Glover, J., Goodwin, T. W., and Morton, R. A., *Biochem. J.*, **41**, 97 (1947).
[23] Krinsky, N. I., *J. Biol. Chem.*, **232**, 881 (1958).
[24] Ganguly, J., Krinsky, N. I., Mehl, J. W., and Deuel, H. J., jun., *Arch. Biochem. Biophys.*, **38**, 275 (1952).
[25] Hubbard, R., and Wald, G., *J. Gen. Physiol.*, **36**, 269 (1952–53).
[26] Brown, P. S. (unpublished observations).
[27] Brown, P. K., and Wald, G., *J. Biol. Chem.*, **222**, 865 (1956).
[28] Hubbard, R., *J. Gen. Physiol.*, **39**, 935 (1956).

EFFECT OF POLYVINYL ALCOHOL ON CHLOROPHYLL AND HÆM IN *CHLORELLA* AND *TENDIPES*

The Level of Chlorophyll in *Chlorella pyridinosa*

IN experiments on *Pisum sativum* L., it was found that polyvinyl alcohol when applied to soil increased the chlorophyll content of the green parts of the plants (ref. 1, and unpublished work by H.F.N. and L.R.). In order to determine what additional factors contribute to this increase we decided to study the alga *Chlorella pyridinosa* which had been bred directly in an aqueous solution of polyvinyl alcohol. Polyvinyl alcohol produced in Poland (known as 'Salvar', 'Polyviol', 'Alvyl', and by other names) was used for these experiments. It was intended to carry out the experiments in aqueous cultures with Pruess medium, on which a rapid growth of *Chlorella* has been observed[2]. However, preliminary experiments showed that one of the elements of that medium, casein, led to errors in measurement. In view of this, cultures from ponds in Białystok were set up in aquaria of 500-ml. capacity. In order to avoid contamination and to remove zooplankton organisms, the culture was filtered by means of a triply folded gauze, after which 400 ml. of the filtrate from the *Chlorella* culture were poured into each aquarium.

The polyvinyl alcohol was prepared as a 10 per cent aqueous solution and different quantities added to the different cultures to give various concentrations of polyvinyl alcohol in them. Concentrations which gave an increase in chlorophyll content were used; they were: 0·00001, 0·0001, 0·001, 0·01, 0·1, 0·5, and 1 per cent. Two aquaria with cultures but no polyvinyl alcohol were used as controls. The experiment lasted 14 days. As early as the tenth day of the experiment, a difference in the intensity of the green colour could be detected with the naked eye. On the fourteenth day of the experiment, 50-ml. specimens were taken from each aquarium and filtered through No. 5 gauzes. The filtered specimens were then dried for three days in a dark room at a temperature of +18° C. Chlorophyll was extracted with ethanol and the content

Table 1. CHLOROPHYLL-LEVEL IN *Chlorella pyridinosa* WITH VARIOUS CONCENTRATIONS OF POLYVINYL ALCOHOL

Concentration of polyvinyl alcohol in culture	Determination I	II	III	Average of the 3 determinations	Average error*
1	0·035	0·028	0·025	0·029	0·00447
0·5	0·075	0·070	0·070	0·071	0·00242
0·1	0·288	0·300	0·316	0·301	0·01180
0·01	0·248	0·248	0·248	0·248	0·00000
0·001	0·172	0·224	0·216	0·204	0·02600
0·0001	0·148	0·176	0·176	0·167	0·01500
0·00001	0·160	0·140	0·140	0·147	0·01260
Control	0·136	0·115	0·100	0·115	0·01260

* The average error was calculated from the formula: $Ed^2/n(n-1)$ where Ed is total divergence from average, n is number of measurements.

of chlorophyll was determined by means of a colorimeter on a wave-length of 650 mμ. 10 ml. of the culture were taken at the same time in order to determine the number of cells. The specimens were fixed in formalin and tested 14 days later.

On calculating the average content in each of the specimens tested, it was found that the level of chlorophyll varied according to the concentration of polyvinyl alcohol used (see Table 1). Comparing the results with those for the controls, it is seen that chlorophyll content increases consistently with the increase in the concentration of polyvinyl alcohol. With 0·001 per cent concentration of polyvinyl alcohol, the amount of chlorophyll was doubled, and the optimal solution used in our experiments (0·1 per cent) practically tripled the amount of chlorophyll. In those cases where the concentrations of polyvinyl alcohol exceeded the optimal, inhibition in development of the algae and a marked decrease in chlorophyll-level was observed (see Fig. 1).

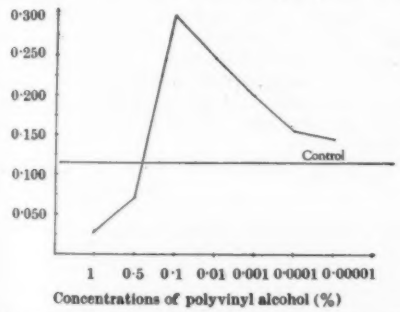


Fig. 1. Curve showing the chlorophyll-level in *Chlorella pyridinosa* cultures of various concentrations of polyvinyl alcohols

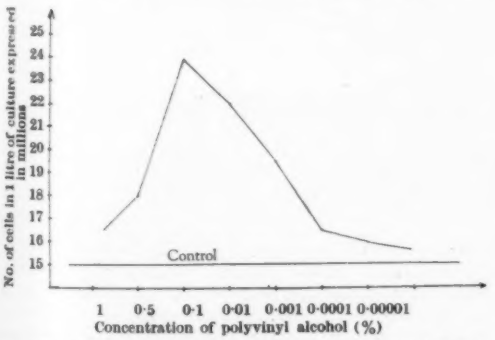


Fig. 2. Curve showing the dependence of the number of cells is dependent on the concentration of polyvinyl alcohol in the culture

The differences in the number of cells were not so marked as the variation in chlorophyll-level. At the optimal concentrations the number of cells as compared with that of the controls showed an increase of only about 60 per cent. These results are presented in Fig. 2.

Aqueous solutions of polyvinyl alcohol have a marked effect on the chlorophyll-level in algae of the *Chlorella* type. This polymer also affects cells, causing an increase in their number. The rise in the level of chlorophyll in *Chlorella* and the increase in the number of cells are not closely connected and are in the proportion of 3·3 : 1. The significant rise in chlorophyll-level in algae growing in aqueous solutions of polyvinyl alcohol may be due to increased intracellular synthesis.

BAZYLI CZECZUGA
LEOPOLD REJNIAK
HENRYK FR. NOWAK

[1] Nowak, H. Fr., and Rejniak, L., *Acta Societatis Botanicorum Poloniae*, **2** (1958).
[2] Pruess, L., Arnow, P., Wolcott, L., Bohones, N., Olson, J. J., and Williams, J. H., *Applied Microbiol.*, **2**, 125 (1954).
[3] Winberg, G. G., and Siwko, T., *Izw. Akad. Nauk B. S.S.R.*, **3**, 61 (1953).

Hæm Content of Larvæ of *Tendipes* f.l. *plumosus* L.

EXPERIMENTS on the effect of polyvinyl alcohol on the chlorophyll content of algae and other plants showed that this polymer at a concentration of 0·0001 per cent doubles the level of chlorophyll. Since chlorophyll has essentially a similar structure to that of hæm, we decided to investigate whether polyvinyl alcohol has a similar effect so far as hæm is concerned.

The experiments were carried out on *Tendipes* f.l. *plumosus* from the ponds in Dojlidy, Białystok. The larvæ were transported to the laboratory and placed in glass aquaria of 500-ml. capacity. 100 c.c. of silt was put at the bottom of each vessel and 250 ml. of pond water, filtered through triply folded gauze, were poured over the silt. The larvæ were transferred to the aquaria, one larva in each vessel, after which an aqueous solution of polyvinyl alcohol was added so that the final concentrations were: 0·001, 0·005, 0·01, 0·05, and 0·1 per cent. One aquarium was left without polyvinyl alcohol as a control. Meanwhile, 50 larvæ from the same place and collected at the same time as the larvæ used for the experiment were dried at a temperature of 105° C. in a drier in order to calculate the average dry mass of one larva. The hæm content found during the experiment was expressed as the proportion to this average dry mass 14 days later. The

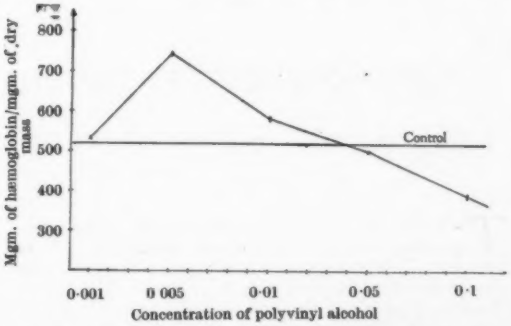


Fig. 1. Graph showing level of hæmoglobin in *Tendipes* f.l. *plumosus* L. in various concentrations of polyvinyl alcohol

larvæ were washed in water several times and transferred in threes to test-tubes containing a mixture of 1 per cent potassium cyanide with 1 per cent potassium ferricyanide in proportion of 1 to 1·5. The hæm content was then determined by the modified Czeczuga method[1].

The results are given on Fig. 1. Each point on the graph was plotted from the average of three measurements. The curve shows that the concentrations of polyvinyl alcohol from 0·001 to 0·1 per cent have a stimulating effect on hæm content. The greatest increase is seen when the solution contained a concentration of 0·005 per cent polyvinyl alcohol. At higher concentrations of polyvinyl alcohol the amount of hæm decreases.

From this experiment and those on increased chlorophyll synthesis, it can be presumed that the same mechanism is operating in both cases. Probably polyvinyl alcohol effects the biosynthesis of the porphyrine parts or makes easier the synthesis of metalloporphyrine.

Henryk Fr. Nowak
Bazyli Czeczuga
Leopold Rejniak

[1] Czeczuga, B., *Roczniki Akademii Medycznej w Białymstoku*, **4**, 134 (1958).

Increase in Level of Chlorophyll in *Pisum sativum* L.

In experiments on the effect of polyvinyl alcohol on the development of *Pisum sativum* L., it was found that plants growing in water cultures to which the substance had been added grow more rapidly than control plants[1]. Polyvinyl alcohol has a similar effect on the growth of the plant mass. We wished to determine whether this substance has the same effect on the growth of *Pisum sativum* in soil to which it had been added as in the aqueous cultures.

For our experiments pea seeds of the variety 'May' were used. Seventy seeds were planted in boxes each containing hot-bed soil. The boxes were then placed in a room where the average daily temperature varied from 22° C. to 4° C. All the boxes were placed on window sills in the same light.

Four boxes with *Pisum sativum* sowings (group 1) were watered with an aqueous solution of polyvinyl alcohol at a concentration of 0·0001 per cent and four boxes (control, group 2) with water. Seventeen days after the plants had germinated, the shoots above ground were measured (from two boxes in each group). Those parts of the shoots which appeared above ground were then cut off in order to determine the amount of fresh plant bulk. Chlorophyll was extracted by the T. Godniewa method and its level determined by means of a Lang photocolorimeter. The plants in the next four boxes were measured and cut on the twenty-second day of the experiment in exactly the same manner. The level of chlorophyll was calculated in mgm. per 1 gm. of fresh shoot mass above ground.

As a standard, a solution of 8 per cent chlorophyll solution appropriately diluted (R. Marck, Darmstadt) was used. The results are given in Table 1.

Table 1. Comparison of the Results of the Experiment
Plants growing in soil to which an aqueous solution of polyalcohol vinyl had been added

Box No.	Date of shoot cutting	Average length of plants	Fresh plant mass in gm.	Amount of chlorophyll in mgm. per gm. of fresh plant mass
1	July 10	27·5 cm.	13,500	2·25
2	,, 10	26·0 ,,	14,100	3·55
3	,, 14	42·0 ,,	24,200	3·66
4	,, 14	44·0 ,,	26,500	3·39
		Control plants		
5	July 10	22·0 cm.	9,650	1·56
6	,, 10	25·5 ,,	13,400	2·23
7	,, 14	34·0 ,,	9,800	3·32
8	,, 14	39·0 ,,	18,500	2·03

The observations presented in our first report[1] on the intensity of coloration in the parts above ground, which is, in our opinion, directly connected with an increase in chlorophyll content, have been confirmed in this experiment.

In series I, the difference in chlorophyll content between plants growing in polyvinyl alcohol and the controls is considerable—1·01 mgm./1 gm. of fresh mass; in series II this difference is 0·85 mgm./1 gm. of fresh mass. The average for series I and II is 0·93 mgm./1 gm. of fresh shoot mass above ground.

This experiment demonstrates that not only in water solutions but also in soil the growth of plants treated with polyvinyl alcohol is more rapid than the growth of control plants.

Leopold Rejniak
Henryk Fr. Nowak
Bazyli Czeczuga
Department of Pathological Anatomy,
and
Biological Laboratories,
Białystok Medical Academy,
Białystok, Poland.

[1] Nowak, H. Fr., and Rejniak, L., *Acta Societatis Botanicorum Poloniae*, **2** (1958).

SOIL MOVEMENT BY DENUDATIONAL PROCESSES ON SLOPES

By Dr. ANTHONY YOUNG
Department of Agriculture, Zomba, Nyasaland

Two aspects of geomorphology which have recently received increased attention are the rate at which changes in landforms take place, and the study of erosional and denudational processes. Estimates of the rate of landform evolution have been made from indirect geological evidence[1–3], or by relating measured river loads[4–6] or rates of sedimentation[7–9] to the catchment areas from which they are derived. These results combine the material removed in bank and bed erosion with that supplied to the rivers by denudational processes. Direct measurements of the rapidity of denudational processes on hill slopes have related mainly to slope-wash, undertaken in connexion with investigations of

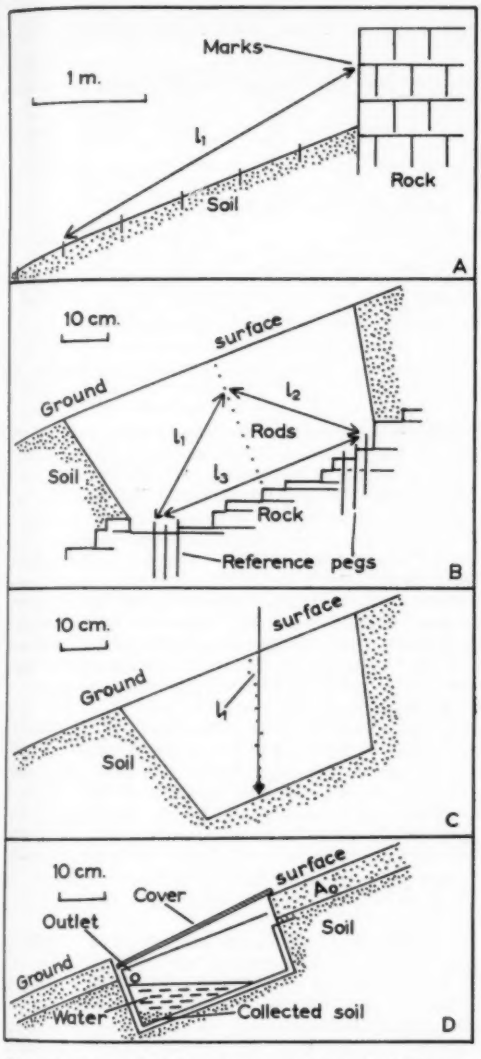


Fig. 1. Techniques for field measurement of the rate of soil-creep and slope wash. l_1, l_2, l_3 are measured lengths

accelerated soil erosion. This article describes techniques evolved for measurement of the rate of soil-creep under natural conditions, and reports interim results; experiments reproducing this process are described, and the relative effectiveness of soil-creep and slope-wash compared.

In the initial attempt at measuring soil-creep, metal pegs were inserted into the ground surface at short distances downslope of a bedrock outcrop (Fig. 1*A*). Three marks were engraved on the rock, and distances from each of these to the pegs measured at intervals of time. Down-slope movements are directly obtained by this method, but their interpretation is uncertain; if the surface soil moves more rapidly than that beneath, it will tilt the pegs, exaggerating movements of their upper ends. Measurements during 3½ years indicate that, on grassed slopes of 30°, down-slope movement close to the ground-surface is of the order of 1 mm. They also show clearly that on slopes steeper than 35°, with a scarred or incomplete turf cover or with terracettes, rate of movement increases rapidly with increase in angle. All results refer to valley slopes in the basin of the Upper Derwent, Southern Pennines, underlain by sandstones with interbedded shales, belonging to the Millstone Grit Series.

To obtain movements of soil in depth, it is necessary to bury markers and afterwards re-excavate, since a vertical soil-face left exposed to the air creates artificial conditions of moisture, temperature and biological activity. Two methods of making such measurements have been employed. In the first (Fig. 1*B*) a pit was dug through the soil to the rock beneath, and six pegs driven firmly into the rock; when filling the pit, these were protected by covers. A line of metal rods (diameter 2 mm., length 10 cm.) was inserted into one side of the pit, the ends of the rods being flush with the undisturbed soil. Measurements from pegs to rods fixed the positions of the latter in two dimensions. In the second method (Fig. 1*C*), a vertical line of fine rods, 1-mm. diameter, was inserted flush with the pit side, and their position measured with respect to a plumb-line suspended close to their ends; on re-measurement, the deepest rods, close to bed-rock, were assumed to have remained stationary. This method is of comparatively high accuracy, but gives only the horizontal component of movement. Nine pits were established, and measured on re-excavation at intervals of 6–12 months over 2 years. Disturbances of rods during burial and excavation were distinguishable as random movements, contrasted with systematic movement of adjacent rods due to soil movement. Results indicate that, on grassed and wooded slopes of 20°–30°, down-slope movement of the upper 10 cm. of soil (excluding the organic horizons) is of the order of 0·25 mm./yr. The unit for measuring volumetric down-slope movement of soil is the volume of soil moved annually across a plane perpendicular to the ground-surface and parallel with the contour of the slope, for unit horizontal distance along the plane, expressed in cm.³/cm./yr. The interim results show a movement of the order of 0·6 cm.³/cm./yr. They also show that movements in the organic A_0 horizon, both under grass and woodland, were very much greater than in the immediately subjacent mineral soil, amounting to 0·5–2·0 mm./yr. It is hoped to obtain more precise results by re-measuring after the pits have been left undisturbed for 3–5 years.

A list of the causes of soil-creep has been given by Sharpe[10]. The majority of these are essentially causes of disturbance in the relative positions of soil particles; down-slope movement is produced by the constant factor of gravity acting on re-adjustments to these positions. Quantitatively, one of the greatest causes of disturbance is the swelling and shrinkage of colloidal components of the soil on wetting and drying. Experiments to reproduce soil-creep by this means have been carried out. Blocks of soil were placed in glass-sided troughs, and pins inserted into the sides of the soil to record movements; the troughs were placed at an angle of 30°, and the soil surface wetted and dried artificially. On wetting, expansion took place perpendicular to the surface; on drying, gravity tends to cause contraction in a vertical direction, but due to cohesion the observed contraction was in a direction intermediate between vertical and perpendicular to the surface. Net down-slope movement

resulted in the manner shown in Fig. 2*A*. Frequently cracks perpendicular to the surface developed, following which each block of soil acted as a separate unit: during expansion a plane of no movement was found up-slope of the centre of the block, and during contraction a corresponding plane down-slope of the centre, resulting in a net down-slope movement of each block (Fig. 2*B*). Difficulty was encountered in preventing movement from occurring mainly at the junction of the soil with the base of the trough, but in some cases differential down-slope movement of the upper layer of soil relative to the lower took place.

Creep due to wetting and drying was further reproduced under semi-natural conditions. An undisturbed block of soil 100 × 20 × 20 cm., with overlying turf, was placed in a glass-sided trough, which was tilted to 25° and exposed to natural weather conditions in Sheffield. Movements were recorded monthly for 2 years. Expansion and contraction of the soil corresponded closely with periods of rainfall and drought. The soil acted as a single block, with movement taking place mainly, but not entirely, along the base, at a rate of 5·0 mm./yr. In a second trough filled to 30 cm. depth with disturbed and re-packed soil, the rate of movement decreased regularly from the surface downwards.

These results suggested an indirect means of measuring soil-creep. At three sites on a slope, on the 26° steepest part and at 18° and 7° on the concavity, variations in moisture content of the soil at three depths were obtained by monthly sampling during 2 years. By means of shrinkage tests, the percentage expansion and contraction of the soil for unit change in moisture content at each of these nine points was obtained. Combining these results and interpolating between the sampled depths gave annual expansion and contraction of the soil on the slope. It was assumed that down-slope movement = sin (slope angle) × expansion and contraction perpendicular to the ground-surface. The results are summarized in Table 1. They show a movement of 0·5–1·0 mm./yr. close to the ground-surface, and 0·05–0·1 mm./yr. below 20 cm. depth. The volume of soil movement is 0·8–1·0 cm.²/cm./yr. The most striking feature is that movement on the 7°-concavity was only slightly less than that of the 26°-slope; this is attributable to the greater fineness of the soil and larger variation in moisture content on the concavity, and probably also to the presence there of expanding-lattice clay minerals.

Table 1

Slope angle	Depth (cm.)	Linear shrinkage for 1 per cent moisture loss* (per cent)	Moisture change +and− (per cent/yr.)	Change in linear dimensions (per cent/yr.)	Down-slope movement (cm./yr.)	Volumetric down-slope movement (cm.²/cm./yr.)
26°	0–5	0·08	37	3	0·86	1·07
	5–10	0·06	20	1	0·41	
	20–30	0·02	11	0·2	0·08	
18°	0–5	0·06	34	2	0·58	0·83
	5–10	0·06	15	1	0·33	
	20–30	0·03	9	0·3	0·08	
7°	0–5	0·10	46	5	0·61	0·79
	5–10	0·14	24	3	0·36	
	20–30	0·04	13	0·5	0·05	

* Prior to residual shrinkage, and corrected for gravel content of soil.

The rate of the movement of the soil by slope-wash was measured on sites close to those used for soil-creep. Tins were placed in the soil with projecting lips on their up-slope sides (length 30 cm.) inserted just below the boundary of the A_1 horizon and the upper surface of the mineral soil (Fig. 1*D*). Soil was collected from the tins at 6–18 month intervals during 3 years. The mean of 49 results was 5·1 gm./yr. of soil, equivalent to a down-slope movement of 0·08 cm.²/cm./yr.

The relative ineffectiveness of slope wash is explicable from the presence of an organic cover, the A_{00} horizon of grass roots or leaf litter and the A_0 humus horizon. Besides their direct protective effect, these have a large capacity for absorbing moisture during storms, afterwards releasing it slowly to the soil beneath. Samples of the humus horizon taken during storms showed it to be capable of holding moisture contents of 75–90 per cent by weight, while retaining a firm structure.

These interim results indicate that on the slopes investigated the rate of down-slope soil movement by soil-creep is of the order of ten times as rapid as that by slope-wash.

This work was assisted by a grant from the Research Fund of the University of Sheffield.

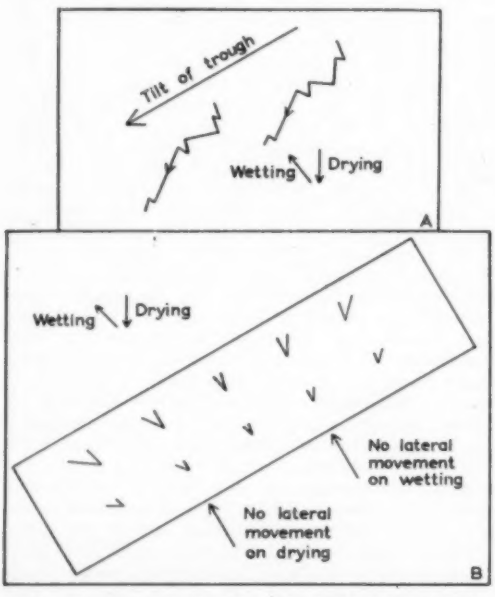


Fig. 2. Movements in a tilted block of soil subjected to alternate wetting and drying. *A*, trace of movements during five periods of drying separated by four of wetting; *B*, diagrammatic representation of movement in a single cohesive block of soil during one cycle of drying and wetting

[1] King, L. C., *Trans. Geol. Soc. S. Africa*, **43**, 153 (1940).
[2] King, L. C., *Bull. Geol. Soc. Amer.*, **67**, 121 (1956).
[3] Linton, D. L., *Adv. Sci.*, **14**, 58 (1957).
[4] Cavaille, A., *Rev. Géomorph. Dynam.*, **4**, 57 (1953).
[5] Wundt, W., *Erdk.*, **6**, 40 (1952).
[6] Corbel, J., *Rev. Géomorph. Dynam.*, **8**, 97 (1957).
[7] Steiner, A., *Geog. Helv.*, **8**, 226 (1953).
[8] Journaux, A., Union Géog. Int., 1r. Rap. Com. Ét. Versants, 133 (Amsterdam, 1956).
[9] Young, A., *Proc. Yorks. Geol. Soc.*, **31**, 149 (1958).
[10] Sharpe, C. F. S., "Landslides and Related Phenomena" (Columbia Univ. Press, New York, 1938).

DISORGANIZATION–ORGANIZATION AND THE RETICULAR FORMATION

By RODABÉ P. BHARUCHA-REID*

Environmental Physiology Laboratory, Department of Physiology, University of California, Berkeley

WHEN a phenomenon seems to defy elucidation, scientists are often forced to 'look before and after' in the hope that the longer route will prove, in the end, to be the shortest. It is perhaps, therefore, that in seeking an answer to the question: 'What is emotion?' that many workers have studied the subsequent effects of an emotional state. While earlier Darwin and Cannon suggested that emotion gave rise to highly organized response sequences (supported in recent times by Leeper, Duffy, and Webb), others, such as Young, have interpreted emotions as leading to disrupting and disorganizing responses. No satisfactory envisagement of the subject of emotions has been arrived at, and Lindsley[1] has suggested that one reason could be that recent neurological findings have rendered certain prominent theories inadequate.

A critical discussion of theoretical compromises and a major experiment relevant to the Leeper-Young controversy has been presented[2]. It was shown that these compromises by Bindra[3] and Hebb[3], as well as the experimental conclusions of Thompson and Higgins[3], were untenable on biological, scientific and logical grounds, and in certain cases actually argue for the disorganization point of view.

Therefore a simple alternative solution is suggested, which proposes that any emotion (or stress) may in effect be disorganizing or organizing, depending on whether there is interference from an internal modulating system, namely, cognitive motivation, which can influence and organize brain activity independent of sensory input in the reticular formation[2,4]; and that emotions are a single sub-class of behaviour to be differentiated from the subsequent effects which may, or may not, be similar to the non-demonstrated effect. The effect of organization would follow from the organism being in such a state of equilibrium with its environment that it may be said to possess the property of adaptability (that is, make for adaption but not necessarily eventuating in it). To ensure that such stability will follow, there is a selection of variables such as not to lead to a critical state (that is, all essential variables lie within their physiological limits). This selection may be automatic as in homeostatic mechanisms (Ashby's principle of ultra-stability), or it may be by the utilization of rational decisions or non-automatic choice as in cognitive motivation. That is, cognitive motivation may be measured by the ratio of maximum use of cognitive control for long-term psychological and physiological survival to a minimum of short-term solutions, overriding all other conflicting needs. By short-term is meant what is temporarily expedient but would not necessarily eventuate, and possibly conflict with survival in the long run; and by psychological survival is simply denoted behavioural equilibrium through a reduction of conflicting responses.

Support for the alternative hypothesis lies not only in experiments which fail to show that stress (or sensory deprivation) necessarily leads to disorganized responses[5], contrary to the McGill experiments on sensory deprivation, but also in the studies using different species and different emotional, intellectual, social, and audio-visual stresses[6]; demonstrating that stress effects on performance should not be studied independently of the cognitive characteristics of the individual, that stress tolerators do their own reality testing, show organized flexible behaviour with no cognitive disruption, while 'quitters' are unable to maintain rational thought and rely heavily on external reality testing. Such a hypothesis explains both the disorganized and the organized, unlike current theories of sensory deprivation which rely heavily on the deprivation characteristics of the stimulating environment to explain only the disorganized. Studies in other areas[7] also demonstrate the consistently dichotomous response of the disorganized-organized individuals in varied situations, as well as in respect to neurophysiological variables (that is, disorganized—'quitters', low-satiation threshold, extroverted, poor control primary processes, rigidity, poor cognitive organization, high reality testing, brain injury, thalamic reticular system; organized—'tolerators', high-satiation threshold, introverted, strong control primary processes, flexibility, strong cognitive organization, low reality testing, normals, brain stem reticular system). It is noted[2] that the satiation phenomenon is centrally involved in these studies and is related to metabolic efficiency (Wertheimer) and the reticular formation[2], while metabolic activity has been related to stress (Pace).

The usefulness of postulating a neurophysiological model for behaviour has been emphasized by Bertalanffy, Hebb, Krech, and Le Gros Clark, and such an attempt is made with dichotomous effects and the intervening internal modulating system. Adrian and Mathews[8] state that anæsthetics may produce 'unconsciousness' by suppressing sensory activity so that behaviour is rigid. It is suggested here[2] that stress essentially replicates the action of pharmaceuticals, thus making stress act as a 'behavioural anæsthetic', and blocking input. Four types of blockage have been discussed in detail[2]. One, differential depressant action, augmenting responses in the non-specific sensory system, by inhibition of the sub-cortical system[9]; second, if sensory input is 'allowed' to be received it is not necessarily elaborated for awareness, depending on inhibition-activation balance sub-cortically[9]; third, cortical stimulation blocks conduction in reticular formation[4], providing a neurophysiological basis for behaviour involving aberrations under emotional stress; fourth, if the alpha rhythm corresponds to the electrical correlate of external sensory input, then the alpha rhythm is readily blocked by concentration of attention,

* Present address: Department of Biology, University of Oregon, Eugene.

Table 1

Brain Stem Reticular		*Thalamic Reticular*
Neurophysiological Characteristics	*Behavioural Characteristics*	*Neurophysiological Characteristics*
Tonic reaction	Adaptation: Long term ..... Short term	Phasic reaction
Long latency period	Threshold: High ..... Low	Short latency period
Response to stimulus long	Sustenance: Long ..... Short	Response rarely outlasts stimulus
Rapid habituation	Habituation: Flexible ..... Rigid	Resistant to habituation
Slow recovery from habituation state	Extinction: Slow ..... Quick	Quick recovery from habituation state
Controls sensory input	Blocking Input .. Suppress or augment cortical activity	Suppressive and facilitory action
Intensity generalization	Ability to cope with intensity changes in stimulation .... High external reality testing	Quality or fine discrimination, continual response to varied stimulus

especially concentration with emotional tone[10]. Simultaneous activity of diffuse-specific projection systems can lead to changes in cortical activity, which is dependent on timing of electrical impulses on the thalamic reticular system[4,10]. Thus it is suggested that sub-cortical blockage of input by stress stimuli delivered at given certain rates would either abolish, increase, or decrease cortical activity (similarly to an artificial stimuli).

Consider now the problem of why performance of the stressed in some cases is organized and in other disorganized (essentially the problem of cognitive motivation). First, studies seem to indicate that the cognitive control mechanism lies in the suppression of reticular activity by the cortex via cortico-thalamic tracts. Integrating the work of Klüver and Bucy, and Forbes and Morrison[11], it would seem that the temporal lobe and amygdaloid complex intact could modulate emotions by affecting brain activity through the secondary sensory discharge. With lesions we obtain uninhibited emotional discharge. The cortex controls the activating mechanism of the brain stem reticular system, thereby influencing its own level of arousal. A second mechanism lies in the activity of the brain stem reticular system, which would have to be prepotent with respect to the thalamic reticular system in order to provide a 'cognitive crutch' for the tolerators of stress, while control by the thalamic reticular system of the alpha rhythm[1], by cutting attention, could provide a 'cocoonizing' response to stress. In the latter case we would have a passive response where reality is ignored temporarily, and in the former case an active apprehension, and a longer lasting if not impervious face to stress. While the thalamic reticular system may provide a subsidiary stress control mechanism, it is proposed that the major function is to lead to disorganized responses as supported by Landis's study[12], as well as the isomorphic relations suggested below.

Finally, the question of how stress or emotion can limit disorganization to certain sense modalities (auditory or visual) or disorganize the whole organism is considered. It is known that the thalamic reticular system can localize its activity to one hemisphere, or even one lobe[10], and I have already proposed that the thalamic reticular system is responsible for disorganizing effects. Another secondary mechanism could lie in the key finding[13] that there is an ordering of the various sensory modes with respect to their effectiveness in inducing cortical activity.

Such rationales for suggesting that the brain stem reticular system and the thalamic reticular system control organized and disorganized behaviour respectively may be considered too tenuous in the face of what we know of brain-behaviour relationships. Undoubtedly such a picture is tentative, and the following isomorphic relationships (between known neurophysiological reactions and known or deduced psychological data) over-simplified. However, there is also support in that these systems control other variables which are related to the dichotomous effects, namely, that of disorganization–organization[2].

Additional effects of stress variability due to change and rate of change of stimulation, and the non-linear relationship between increased stress and increased disorganization are discussed with respect to experimentation[2]. Further considered is the influence of individual (especially satiation-level) and cultural factors on disorganization–organization, neurochemical composition of the reticular formation and learning, old-age as a 'natural' sensory deprived group, and the utilization of brain injured and 'quitters' as catalysts for research in concept formation[2].

This research was supported in part by Contract No. *AF*41(657–258), from the Arctic Aero-Medical Laboratories, Alaska. Acknowledgment is also made to those who helped in the formulation of the full text (ref. 2).

1 Lindsley, D. B., in "Handbook of Experimental Psychology", 473 (J. Wiley, New York, 1951).

2 Bharucha-Reid, R. P., "Disorganization-Organization, Cognitive Motivation and the Reticular Formation" (submitted for publication).

3 Bindra, D., *Canad. J. Psychol.*, **9**, 161 (1955); Hebb, D. O., "The Organization of Behaviour" (J. Wiley, New York, 1949); Thompson, W. R., and Higgins, W. H., *Canad. J. Psychol.*, **12**, 61 (1958).

4 Samuels, I., *Psychol. Bull.*, **56**, 1 (1959).

5 Butler, R. A., *Amer. J. Psychol.*, **71**, 591 (1958); Myers, T. I., "HumRRO Study," Monterey, California; Schachter, S., "The Psychology of Affiliations" (Stanford University Press, Stanford, 1959); Vernon, J., and Hoffman, J., *Science*, **123**, 1074 (1956).

6 Broverman, D. M., and Lazarus, R. S., *J. Pers.*, **26**, 94 (1958); Bruner, J., in "Symposium on Sensory Deprivation" (Harvard University Press, Cambridge, 1958) (in the press); Goldberg, L., and Holt, R., *ibid.*

7 Eyesenk, H. J., *J. Abnorm. Soc. Psychol.*, **51**, 94 (1955); Klein, G. S., and Krech, D., *J. Pers.*, **21**, 118 (1952); Petrie, A., Collins, W., and Solomon, P., *Science*, **128**, 1431 (1958); (2) *ibid.*; Butler, R. A. (5) *ibid.*; (6) *ibid.*

8 Adrian, E. D., and Mathews, B. H. C., *J. Physiol.*, **81**, 440 (1934).

9 Brazier, M. A. B., in "Brain Mechanisms and Consciousness", 163 (C. Thomas, Springfield, Ill. 1954).

10 Jasper, H. H., in "Biology of Mental Health and Disease", 226 (P. Hocher, New York, 1952).

11 Klüver, H., and Bucy, P. C., *Archiv. Neurol. Psychiat.*, **42**, 979 (1939); Forbes, A., and Morrison, B. R., *J. Neurophysiol.*, **2**, 112 (1939).

12 Landis, C., in "Biology of Mental Health and Disease", 262 (P. Hocher, New York, 1952).

13 Chow, K. L., Dement, W. C., and John, E. R., *J. Neurophysiol.*, **20**, 482 (1957).

CONCENTRATION OF SOME FISSION PRODUCT NUCLIDES IN GROUND-LEVEL AIR

By K. EDVARSON and KERSTIN LÖW
Research Institute of National Defence, Department 4, Stockholm 80

IN ground-level air the fission product activity originating from nuclear weapon tests varies considerably with time, both in intensity and composition. In order to map these variations, especially regarding the long-lived components, γ-spectrometric measurements have been made on monthly samples of ground-level air taken near Stockholm, Sweden. An attempt has been made to correlate the activity variations with known nuclear weapon tests.

The sampling apparatus consisted of a commercial centrifugal blower (Stephan-Werke, Hameln/Weser, West Germany), to which a filter holder (area 18 × 18 cm.²) was attached on the inlet side. The filter medium was glass-fibre paper with a thickness of 55–60 gm./m.². The filtering capacity was about 4 kgm. air per min.

The samplers were run continuously, and the filters changed every 24 hr. Thus, each sample contained the particulate activity from about 5,000 kgm. air.

The samples were allowed to stand for 3 days in order to let the short-lived radium and thorium daughter products decay. After that, one quarter of the sample was measured for total γ-activity with a scintillation counter. (The remainder was used for autoradiographic and other investigations.) When the measured samples were strong enough (> 2 nc.), individual nuclides were determined by γ-spectrometry. These measurements of daily samples are reported elsewhere[1,2]. The samples were then pooled to give monthly, or sometimes half-monthly, samples. The γ-spectra of these pooled samples (each corresponding to (1–4 × 10⁴ kgm. air) were measured with a spectrometer consisting of a 10 cm. × 10 cm. sodium iodide(T1)-crystal connected to a 70-channel kick-sorter.

The results given in this article cover the period September 1957–December 1959 for a sampling station near Stockholm (59·2° N., 18·1° E.). The measurements were mainly performed at the end of 1959 and beginning of 1960, and the concentrations of zirconium-95, antimony-125, cæsium-137 and cerium-144 were determined. The results are given in Table 1, where all activities have been recalculated to October 18, 1959. For the period May 1958–September 1958 the zirconium-95 values were obtained from measurements made in June 1959. For older pooled samples zirconium-95 values are lacking. Contributions to the γ-spectra were also observed from ruthenium-(103 + 106). The relative amounts of ruthenium-103 and -106 could not be determined as their main γ-lines are quite close in energy. An indication of manganese-54 was also observed in most of the samples. In samples from the second half of 1959, which were measured a few months after sampling, beryllium-7 (54 *d*) was also detected. In these samples it has not yet been possible to determine the antimony-125 content, because the γ-line of this nuclide is masked by the one from beryllium-7.

In Fig. 1 the time-variation of the concentration of cæsium-137 is plotted. The main features are two broad peaks with half-widths of 4–6 months and maxima in June 1958 and May 1959, respectively. A temporary increase is observed in October 1957. From earlier measurements on daily samples, it has been found that about 75 per cent of the cæsium-137 activity during this month was collected in one sample (October 13–14). In this sample, considerable amounts of iodine-131, presumably originating from the Windscale accident, were found, and probably most of the cæsium-137 has the same source. In Figs. 2, 3, 4 and 5 the values for zirconium-95 and the zirconium-95/cæsium-137, cerium-144/cæsium-137 and antimony-125/cæsium-137 ratios are plotted. The rather sharp increase of the concentration of zirconium-95 at the end of 1958, combined with the increase in the zirconium-95/cæsium-137 ratio, is a proof of the appearance of activity of considerably more recent origin. From more detailed age-determinations (for example, from the barium-140/(zirconium + niobium)-95 ratio) made on debris sampled during the end of 1958 and beginning of 1959, it was concluded that this debris originated mainly from October 1958. According to Press data, Russian high-yield tests were performed during October 12–22, 1958.

In the following an attempt is made to calculate the possible dates of origin and mixing ratios of the debris by comparing the measured zirconium-95/

Table 1

Period of sampling		Measuring date	Zr-95 (pc./kgm. ×10³)	Sb-125 (pc./kgm. ×10³)	Cs-137 (pc./kgm. ×10³)	Ce-144 (pc./kgm. ×10³)
Sept. 57		3.3.60		0·6	2·8	4·0
Oct.		2.3		1·2	11·4	9·8
Nov.		29.2		1·0	2·7	8·5
Dec.		25.2		1·2	3·7	10·8
Jan. 58		16.2		(0·8)	3·2	9·3
Feb.		17.2		(0·8)	3·9	11·2
March		15.2		2·1	7·4	26·9
April		15.2		3·4	11·1	39·2
May		4.2	1·2	6·3	16·9	64·3
June		5.2	1·5	8·6	22·9	84·3
July		4.2	1·4	6·5	16·5	70·4
Aug.		5.2	0·8	3·0	7·5	29·0
Sept.		6.2.60	1·5	3·2	8·4	44·8
Oct.		10.11.59	2·3	1·8	7·0	41·1
Nov.		11.11	7·6	1·9	5·5	54·1
Dec.		11.11	8·1	1·6	5·5	47·3
Jan. 59	1	28.10	11·3	2·5	5·9	60·0
	2	28.10	27·5	7·4	13·6	147
Feb. 59	1	29.10	35·9	10·7	18·2	195
	2	2.11	33·3	8·3	16·4	174
Mar. 59	1	2.11	40·7	8·9	23·2	215
	2	3.11	68·9	15·6	35·7	353
April 59	1	4.11	37·1	10·7	21·0	208
	2	4.11	58·7	17·6	35·4	330
May 59	1	6.11	83·8	24·8	44·2	428
	2	6.11	65·0	18·5	36·5	336
June		7.11	49·2	14·4	27·8	251
July		7.11	29·9	10·1	20·0	159
Aug.		9.11	10·4	< 4·1	8·2	59·8
Sept.		10.11	3·2		3·0	18·4
Oct.		27.11	2·3		2·4	16·5
Nov.		11.12.59	1·2		1·5	8·8
Dec.		13.1.60	1·3		1·5	8·4

The concentration of the measured nuclides have been recalculated to October 18, 1959, using the following half-lives: zirconium-95, 65 days; antimony-125, 2 years; cæsium-137, 30 years; cerium-144, 285 days. As no absolute calibration has been made for antimony-125 the absolute values of this nuclide may be in error by ± 30 per cent.

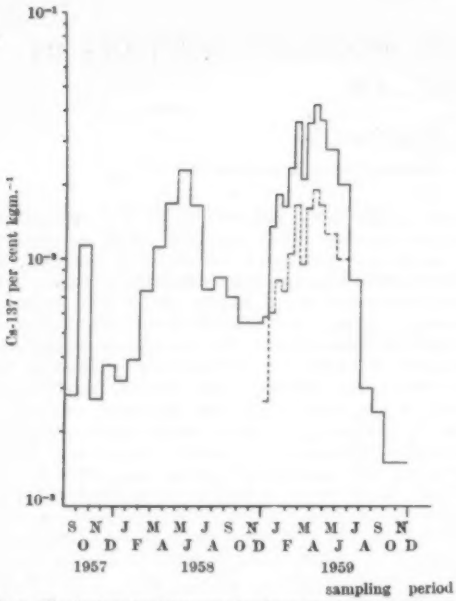


Fig. 1. The broken-line histogram has been obtained by subtracting the maximum contribution from the October 1958 tests

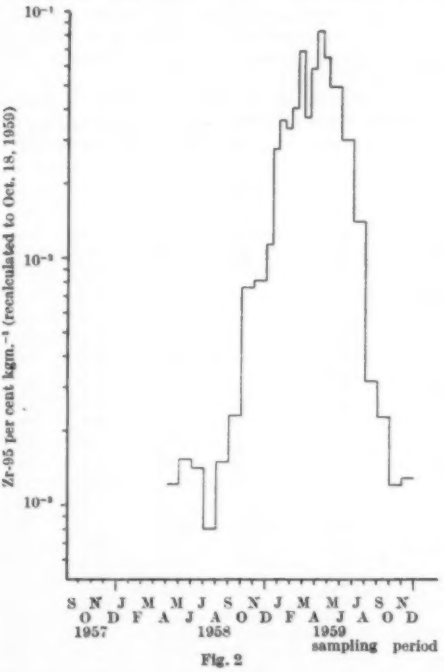


Fig. 2

cæsium-137 and cerium-144/cæsium-137 ratios with calculated values. The calculation of these ratios implies large uncertainties as the type of fission (fissionable material, neutron energy-spectrum) can only be roughly estimated, and furthermore, the yield-values are quite uncertain in many cases. In Table 2 yield values for the possible fission modes are given[3]. Mean values of the yields for fast and

Table 2. Yield Values (per cent)

Mass chain	Type of fission: U-235 fast	U-238 fast	Pu-239 fast	U-235 14 MeV.	U-238 14 MeV.
95	6·74	5·64	5·16	5·24	5·21
125	0·122	0·052	0·254	1·33	1·09
137	6·16	6·13	6·07	5·14	5·62
144	4·75	4·55	3·62	3·24	3·23

14-MeV. fission of uranium-238 have been used for the calculations.

A source of error is also introduced by fractionation phenomena[4]. For example, it has been found experimentally that the mass-chain 95 is enriched in larger particles, which can be explained from the chemical properties of the fission products during the period of particle formation. To estimate the influence of this on the ratios studied it is necessary to have some knowledge of the particle spectrum. Such work is under way at this laboratory. Although the quantitative evaluation of the particle spectra is not yet concluded, it is possible to say that the contribution of larger particles with appreciable fractionation to the total activity is small for debris older than about three months. For this reason we assume in the following that, except for debris with components younger than a few months, the error due to fractionation is small compared with errors in the measurements and theoretical calculations.

In Figs. 3 and 4 the calculated ratios for the publicly known high-yield explosions on the northern hemisphere since 1957 have been indicated (cf. Table 3). It is observed that the experimental zirconium-95/cæsium-137 ratio for the first six months of 1959 is nearly constant, and about 0·6 times the theoretical ratio for debris from October 1958, thus indicating an admixture of older debris.

In Fig. 6 the theoretical relationship between the zirconium-95/cæsium-137 and cerium-144/cæsium-137

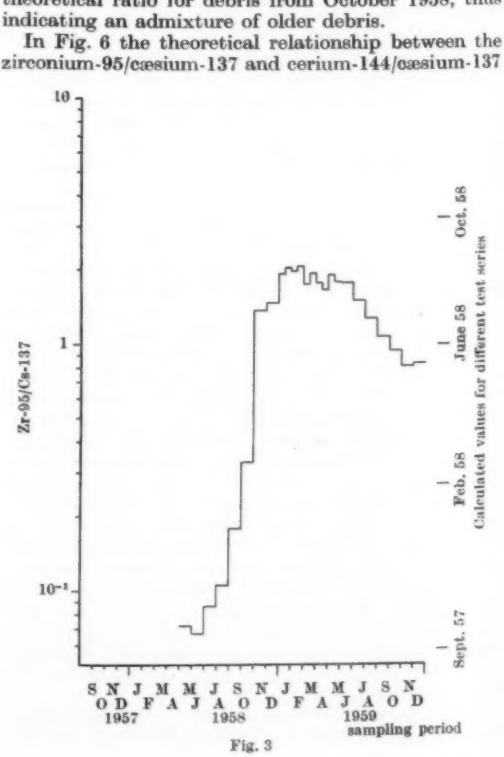

Zr-95/Cs-137
S N J M M J S N J M M J S N
O D F A J A O D F A J A O D
1957
1958
1959
sampling period
Sept. 57
Feb. 58
June 58
Oct. 58
Calculated values for different test series

Fig. 3

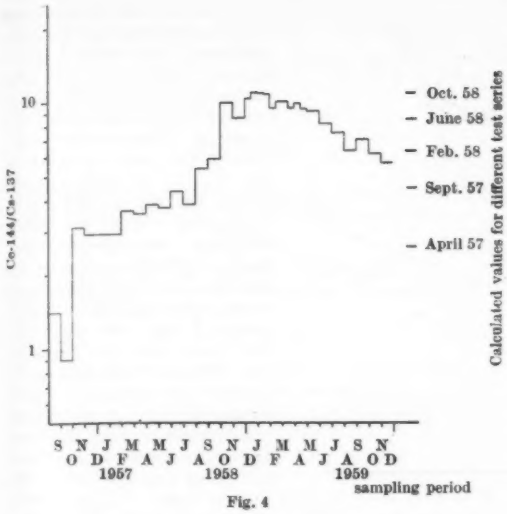

Ce-144/Cs-137
10
1
Oct. 58
June 58
Feb. 58
Sept. 57
April 57
Calculated values for different test series
S N J M M J S N J M M J S N
O D F A J A O D F A J A O D
1957 1958 1959
sampling period

Fig. 4

ratios is given for mixtures where one component originates from October 1958 and the remainder is from June 1958 or earlier. The ratios refer to October 18, 1959. The K-values are the fraction of cæsium-137 originating from October 1958. A binary mixture is given by a straight line in the diagram between the points representing the pure components. A point on this line defines a K-value. If this value is kept constant and the origin of the older component is varied from very old (that is, zirconium-95/cæsium-137 and cerium 144/cæsium-137 $\approx$ 0) to June 1958, an arc is obtained (for example, $ABCD$). All mixtures of two or more components with a given K-value will be represented by points in the area obtained by connecting the ends of this arc by a straight line.

By inserting observed values in Fig. 6, some indication of the mixing-ratios and the age of the older components can be obtained.

For an evaluation of the uncertainty in this estimation, it is necessary to consider both the errors in the experimental and the theoretical values. The former are partly statistical and partly systematic, due to difficulties in the interpretation of the γ-spectra. The latter are systematic and are a result of uncertainties in yield values and half-lives, as well as fractionation. From a practical point of view, it is advantageous to attribute all these errors to the experimental points and regard the theoretical values as fixed. An indication of the magnitude of the statistical errors is given by the measurements from the period January–June 1959, during which no systematic variation in the observed ratios could be seen. From an analysis of these values, it is found that the standard deviations are 6 per cent for the ratios zirconium-95/cæsium-137 and cerium-144/cæsium-137, and 3 per cent for the zirconium-95/cerium-144. The systematic errors from uncertainties in yield values and half-lives can be roughly estimated to 15–20 per cent. As an estimate of the total maximal errors, the following values have been chosen: zirconium-95/cerium-144, 20 per cent; cerium-144/cæsium-137, 25 per cent; and zirconium-95/cæsium-137, 25 per cent.

In Fig. 6 an experimental point corresponding to the mean values for the sampling period January–June 1959 has been inserted. Adding the errors as assumed above, a hexagonal area as indicated in the figure is obtained. As this area is rather large, no very accurate conclusions about mixing ratios can be made. However, it can be seen that between 20 and 55 per cent of the cæsium-137 originates from October 1958, and that a large part of the older component emanates from September 1957 or later. The experimental points for the second half of 1959 indicate an increased mixing ratio of older components with time, and the mean age of these older components also seems to increase with time. This trend can be considered significant, as the greater part of the assumed errors is systematic and to a large extent common for all points.

From the possible mixing ratios for samples from 1959, estimated as above, it is concluded that between 50 and 100 per cent of the zirconium-95 in these samples can be attributed to the October 1958 tests. The activity of zirconium-95 plotted in Fig. 2 thus gives, as regards 1959, a fairly good picture of the time-variation of the activity of this origin (corrected for radioactive decay). The maximum occurs about 6 months after the tests, and has a half-width of 5–6 months. The peak value corresponds to (1–2) $\times$ 10^7 fissions per kgm. air. One year after the tests the level is only a few per cent of the maximum value.

Only 55 per cent of the cæsium-137 peak in the spring 1959, given in Fig. 1, can originate from October 1958, as concluded from Fig. 6. If this contribution is subtracted from the total cæsium-137 activity, a pronounced peak still remains. It thus seems that the peak in 1959 consists of two com-

Table 3. HIGH-YIELD EXPLOSIONS ON THE NORTHERN HEMISPHERE 1957–58

Test period	Country	Explosion date used in the calculations
April 3–16, 1957	U.S.S.R.	April 10, 1957
Aug. 22–Oct. 6, 1957	U.S.S.R.	Sept. 15, 1957
Feb. 23–27, 1958	U.S.S.R.	Feb. 25, 1958
June 28, 1958	U.S.A.	June 28, 1958
Sept. 30–Oct. 24, 1958	U.S.S.R.	Oct. 18, 1958

The American tests in August 1958 are not included as they were performed at very high altitude. Nor have the British tests at Christmas Island been included.

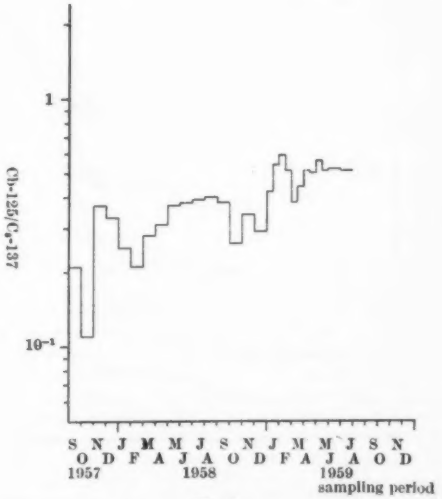


Fig. 5

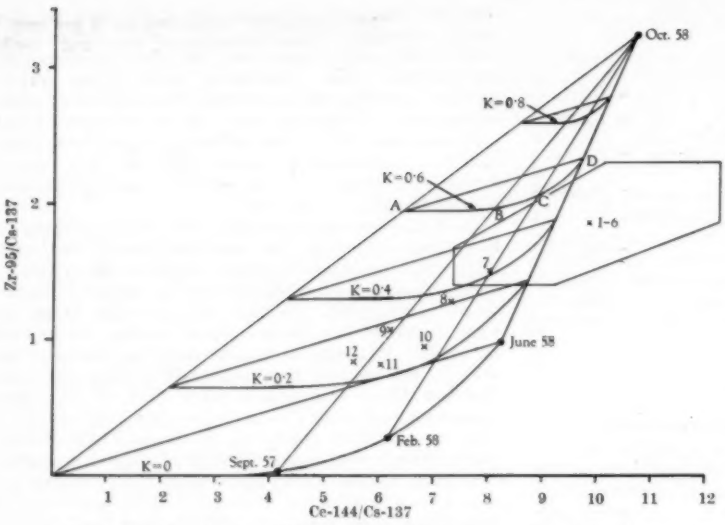


Fig. 6. X, observed values. The numbers 1–12 indicate sampling months, 1959

ponents, both of which have approximately the same shape. These results are consistent with the observations reported by Ambrosen[5] on activity in precipitation and by Peirson *et al.*[6] on tropospheric activity, that about 50 per cent of the long-lived activity, sampled in the first six months of 1959, emanated from October 1958.

By a similar analysis of the results during May–July 1958 (Fig. 7) it is found that at most 30 per cent of the cæsium-137 emanates from February 1958, and a large part of the remainder comes from 1957. During the autumn of 1958, the cæsium-137 level is fairly constant and high compared with the same period in 1959. A possible reason for this is the February 1958 tests, if it is assumed that these tests gave a contribution of the same type as the October 1958 tests with a maximum about six months after the tests.

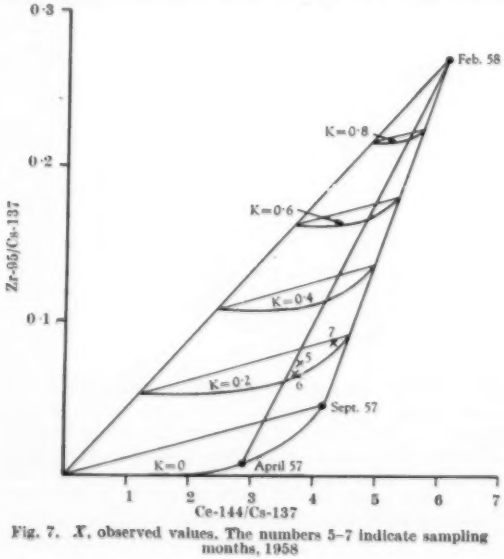


Fig. 7. X, observed values. The numbers 5–7 indicate sampling months, 1958

The additional information that can be obtained from the antimony-125 values is rather limited because of the large variation in yield with fission mode for this mass-chain (cf. Table 2). The antimony-125/cæsium-137 ratio is given in Fig. 5. It is seen that the values for the period April–September 1958 are fairly constant, and have a mean value of 0·37, whereas the period April–July 1959 has a mean value of 0·52. If it is assumed that the antimony-125 yields are the same for the different injections, this increase corresponds to a decrease in age of about one year; that is, that the mean age of the debris at the time of sampling was the same. The rather large variations for September 1957–March 1958 and October 1958–January 1959 might be due to experimental errors in the determination of antimony-125, as the samples from these periods were very weak.

The main feature of the observations reported in this article and elsewhere[7] is a pronounced seasonal variation of the cæsium-137 content in ground-level air during 1958 and 1959. This, however, does not necessarily imply a seasonal variation in the transport properties of the upper atmosphere, as the major injections of debris in high northern latitudes took place in the autumns of 1957 and 1958, and the variations thus may be explained by assuming a mean residence time in the stratosphere of about six months for such debris, independent of the time of injection. Only when the contributions from the preceding autumn have been subtracted from the total content is it possible to get a fairly unequivocal indication of a 'true' seasonal variation. As is found, a pronounced variation of this type seems to exist during 1959 and there are indications of it during 1958. These observations are thus in concordance with the model of stratospheric fall-out presented by Stewart[8] and Machta[9].

However, it has not been verified that this type of variation applies to injections at high latitudes. As is pointed out by Martell[10], there are indications that the mechanism of stratospheric fall-out from such injections differs in such a way that the residence time is considerably shorter (~ 6 months) than for injections at low latitudes, and not very dependent on the time of the year. The results presented here do not contradict this theory. On the contrary, some features seem to support it, for example, the relatively high cæsium-137 values during the autumn of 1958 which may be due to the February 1958 tests.

[1] Lindblom, G., Report F.O.A. 2, *A*, 2053–2097/1959.
[2] Lindblom, G., Report F.O.A. 4, *A* 4102–2097/1959.
[3] Prawitz, J. (private communication).
[4] Edvarson, K., Löw, Kerstin, and Sisefsky, J., *Nature*, **184**, 1771 (1959).
[5] Ambrosen, J., *Nature*, **185**, 301 (1960).
[6] Peirson, D. H., *et al.*, *Nature*, **186**, 224 (1960).
[7] Schumann, G., and Eulitz, G., *Naturwiss.*, **47**, 13 (1960).
[8] Stewart, N. G., *et al.*, A.E.R.E., *HP/R* 2354 (1957).
[9] Machta, L., *Proc. U. S. Nat. Acad. Sci.*, **45**, 1672 (1959).
[10] Martell, E. A., *Science*, **129**, 1197 (1959).

LETTERS TO THE EDITORS

PHYSICS

Magnetoresistive Measurements on Domain Rotation in Nickel - Iron Alloy Films

For low saturating magnetic fields, the magnetoresistive effect in a polycrystalline ferromagnet is described by the relation[1]:

$$\Delta R = \Delta R_0 \cos^2\varphi \qquad (1)$$

where ΔR_0 is the positive resistance change measured when the electric current i is oriented first normal then parallel to the saturation magnetization M_s; and φ is the angle between the current and the induction. This relation has been verified for evaporated nickel films by Rappeneau[2].

A film which has uniaxial anisotropy energy E is described by the relation $E = K \sin^2\theta$, where θ is the angle between M_s and the direction of minimum anisotropy energy, called the K-axis. If such a film is magnetized by a field $H_\perp$ in the film plane normal to the K-axis, the equilibrium angle θ for any field less than, or equal to, $H_K = 2K/M_s$ is given by:

$$\sin\theta = h_\perp, \quad h_\perp = H_\perp/H_K \qquad (2)$$

provided that the magnetization rotates uniformly in the plane of the film[3,4]. If the current is normal to the K-axis, substitution of $\sin^2\theta$ for $\cos^2\varphi$ in equation (1) yields:

$$\Delta R/\Delta R_0 = h_\perp^2 \qquad (3)$$

If the current is parallel to the K-axis, the result is $\Delta R/\Delta R_0 = 1 - h_\perp^2$. Thus, a plot of $\Delta R/\Delta R_0$ against $h_\perp$ should be a parabola over that range of $h_\perp$ for which equation (2) is valid in a given film.

Fig. 1*a* shows the magnetic hysteresis curves for a field-evaporated 80–20 nickel–iron film, 2000 Å. thick, magnetized by a sinusoidal field of 500 c./s. of amplitude $\hat{H}_\perp$ normal to the K-axis. The closed loop at low field demonstrates the applicability of equation (2), see refs. 3, 4. The value of field at which this curve is extrapolated to saturation is usually taken as a measure of H_K. Figs. 1 *b*, *c* and *d* are the magnetoresistive hysteresis curves taken for those values of $\hat{H}_\perp$ in Fig. 1*a*. The measuring circuit used to obtain the latter is described by Hellenthal[5]; namely, a sinusoidal magnetizing field (20 c./s.) produces, as a result of the magnetoresistive effect, an alternating voltage across a film through which a constant direct current (30 m.amp.) is passing. The voltage is amplified and displayed on the vertical plates of an oscilloscope. The magnitude y of the vertical display is proportional to ΔR, while the horizontal display x is proportional to $H_\perp$. The voltage to produce x comes from the voltage drop across a resistance in series with the magnetizing coils. In the present experiment, the films are rectangular (5 mm. × 20 mm.) and deposited on soft glass.

For these experimental conditions the magnetoresistive curve for $\hat{H}_\perp$ sufficiently small should be a parabola described by equation (3). Fig. 1*b* shows that such is indeed the case. Figs. 1 *c* and *d* show

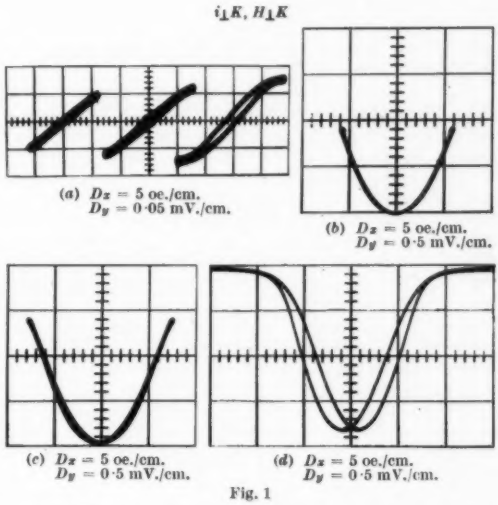


Fig. 1

that as $\hat{H}_\perp$ is increased the parabola opens up, and hysteresis occurs. Fig. 1*d*, for $h_\perp > 1$, is especially significant. The maximum change of d.c. resistance ΔR_0 for this film was found to be 0·060 ohm by potentiometric measurements in a static magnetic field. This value agrees with that calculated from the maximum change y_0 in Fig. 1*d* to within the accuracy of both measurements (±5 per cent). This result has been verified for all the films which have been studied (Table 1), and it indicates that the process of magnetization when $H_\perp$ is applied is predominantly one of domain rotation accompanied by rotational hysteresis.

Table 1

Sample	1	2	3	4
Thickness (cm.) × 10^5	2·00	2·00	0·62	0·62
$\Delta R_0/R$	0·0058	0·0058	0·0185	0·0170
ΔR_0 (ohm) d.c. measurement	0·060	0·052	0·246	0·215
ΔR_0 (ohm) corresponding to y_0	0·060	0·052	0·24	0·18
H_K (oe.) magnetic	9·0 (6)	8·0 (6)	7·0 (5)	4·0 (3)
	8·5 (8)	8·0 (8)	—	—
	6·5 (10)	7·0 (10)	—	—
H_K (oe.) magnetoresistive	8·3 (6)	7·3 (7)	7·8 (5)	4·7 (2)
	8·8 (8)	—	—	—
	6·6 (25)	6·6 (25)	—	—

Numbers in parentheses are values of $\hat{H}_\perp$ at which H_K was determined

These observations, together with those of Bradley and Prutton[6,7], suggest the following description of the transverse magnetization process in nickel–iron alloy films having uniaxial anisotropy. When the film has been previously saturated along the K-axis and $H_\perp$ is sufficiently small, the process is one of uniform reversible rotation of the magnetization within the plane of the film. However, with increasing $H_\perp$, the local deviations of the direction of anisotropy within the film as proposed by Harte[8], together with the demagnetizing field of the film relative to the average K-axis, make it favourable for some regions

of the film to rotate abruptly into the equivalent antiparallel directions, thus forming more or less oppositely directed domains bounded by walls of something less than 180°. At the higher values of $H_\perp$, rotation within these domains occurs. The local deviations of the direction of anisotropy account for the rotational hysteresis. This idea is supported by the experimentally observed fact that those films which have less hysteresis for $h_\perp > 1$ obey equation 3 to larger values of $H_\perp$ ($h_\perp < 1$).

Fig. 1*b* suggests the use of equation 3 to determine H_K. To within the accuracy with which y_0 represents ΔR_0, equation (3) can be written as $y/y_0 = (xD_x/H_K)^2$, where D_x is the horizontal scale factor in oe./cm. Photographic enlargements of the oscilloscope traces are projected on to graph paper from which x, y, and y_0 are measured. The slope of the linear portion of a plot of y against x^2 is used to calculate H_K. Fig. 2 shows such plots for the traces of Figs. 1 *b*, *c* and *d*. That for Fig. 1*d* corresponds to one lobe of the hysteresis curve. The initial slopes yield values of H_K in agreement with the extrapolated linear portions of the magnetic hysteresis curves in Fig. 1*a*. Table 1 lists the values of H_K obtained by the two methods for four films. These values are in agreement to within the accuracy of the magnetic method. It is perhaps significant that H_K as measured by either method is dependent on the amplitude of the sinusoidal magnetizing field.

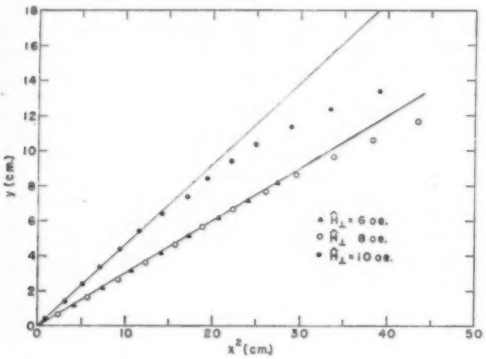


Fig. 2

For film studies there are some advantages in the magnetoresistive method. The proportionality of the signal to the square of the cosine of the angle between current and magnetization and the independence of the signal on rate of magnetization make it possible to distinguish experimentally between domain rotation and 180°-wall motion. Furthermore, the independence of rate makes observation of the magnetization process at low magnetizing frequencies particularly easy. Compare the signal-levels obtained from the two methods at 500 c./s. and 20 c./s. (Fig. 1). The direct current in this case was 30 m.amp.; however, it is limited only by the maximum safe current density. For this particular film, currents as high as 300 m.amp. have been applied with no apparent ill effects. The large ratio of surface to volume of a film is favourable for the dissipation of Joule heating. Finally, the simplicity of the magnetoresistive method makes it particularly useful for remote measurements; for example, in a cryostat, or *in vacuo*.

The samples were prepared in this laboratory by R. E. Wimberly, J. W. Chambers and L. J. Boudreaux.

Forrest G. West

Solid State Physics Department,
Central Research Laboratories,
Texas Instruments Inc.,
P.O. Box 1079,
Dallas 21, Texas.

[1] Bozorth, R. M., "Ferromagnetism", 754 (Van Nostrand Co., New York, 1951).
[2] Rappeneau, T., *C.R. Acad. Sci., Paris*, **246**, 571 (1958).
[3] Smith, D. O., Conference on Magnetism and Magnetic Materials, Boston, October 1956 (Amer. Inst. Elect. Eng., 625 (Feb. 1957)).
[4] Smith, D. O., *J. App. Phys.*, **29**, 264 (1958).
[5] Hellenthal, W., *Z. Naturforsch.*, **14**, *a*, 1077 (1959).
[6] Bradley, E. M., and Prutton, M., *J. Electronics and Control*, **6**, 81 (1959).
[7] Prutton, M., *Phil. Mag.*, **4**, 1063 (1959). Dr. Prutton has independently arrived at a similar description of the transverse magnetization process (private communication).
[8] Harte, K. J., *J. App. Phys.*, **31**, 283*S* (1960).

Electrical Conductivity of Strontium Oxide

The part which strontium oxide plays in the functioning of the oxide cathode is not well understood; a suitable model of the combined barium and strontium oxides on the band theory is still not satisfactory. Further, lack of sufficient observations in the soft X-ray region over the operating temperature-range prevents a fuller knowledge of how the valence band densities are related in the solid solution of the oxides. It is, of course, possible to go some way towards understanding the oxide cathode if the main and relevant properties of each component can be studied.

With this in view, we have concentrated attention on the electrical properties of strontium oxide and find, using a double platinum 'probes' technique, that the electrical conductivity (d.c.) varies with the applied voltage over the temperature-range (823–1182° K.) in the manner shown in Fig. 1. The voltage between the probes has been plotted rather than the field, since the latter is bound to be 'patchy' owing to the presence of a non-uniform porous dielectric.

It is remarkable that, in contrast to the behaviour of barium oxide, the electrical conductivity varies with the field; there appear to be two transitions involved—one due to the field, the other due to temperature. A 'knee' is seen to develop at an applied voltage of about 20 V., and the conductivity is sensitive to the effects of the field only below this, or above 1013° K. Why, at this particular temperature and field, strontium oxide behaves according to classical theory (with the usual assumptions) is not clear; the fall in conductivity with field at the lower temperatures is curious, and might be attributed to electrostatic effects, accompanying changes in current density, between irregular crystallites which affect and alter the contact resistance between them.

The change of slope from negative to positive at the knee voltage around 1013° K. indicates a predominating effect due purely to thermionic emission; indeed, this could explain the rise of conductivity with field wherever it is observed on the curves. A rough estimate of the effect shows that the Langmuir–Child space charge law has a maximum index of about 1·3, and could be fitted to each set of results

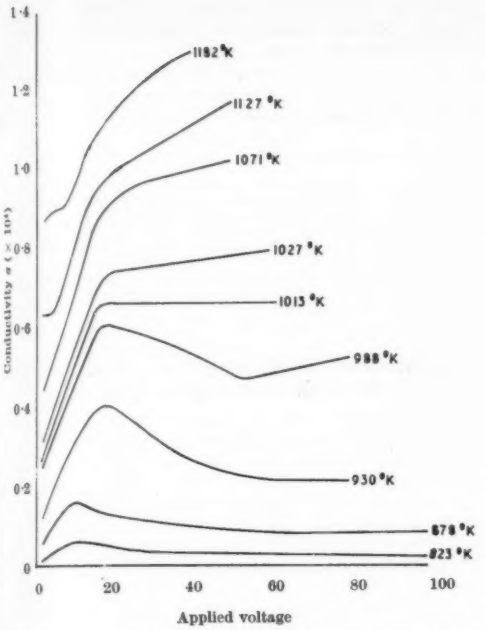


Fig. 1. Electrical conductivity (d.c.) of strontium oxide as a function of applied voltage over the temperature-range 823–1182° K.

above 1013° K. over the whole range of applied voltage. This is interesting in itself.

Some confirmation of this interpretation comes from the results with alternating currents (5 kc./s.); there was no fall in conductivity with field and no plateau at 1013° K. Contact with oxygen at 10^{-3} mm. mercury pressure of the well-activated strontium oxide surface scarcely affected the a.c. conductivity, which still showed the same features of temperature and field; this was much enhanced on contact with hydrogen. The results so far show that oxidation and reduction treatments produce a desirable quality—a conditioning towards a homogeneous oxide.

M. J. Adams
L. Jacob

Natural Philosophy Department,
Royal College of Science and Technology,
Glasgow, C.1.

Soft Ultra-violet Photons in Self-quenching Geiger-Müller Counters

Though it is now certain that, in a self-quenching Geiger-Müller counter filled with a conventional argon-alcohol mixture, both photo-ionization[1] and photo-emission[2] cause the spread of the discharge along its anode, the production of ultra-violet photons which are responsible for these two processes and their relative importance in determining the counter characteristics have not yet been fully understood. Further, no reliable data are available for the energy spectrum of these photons, which may be emitted by any of the following mechanisms: (1) de-excitation of excited argon atoms formed in Townsend avalanches giving rise to wave-lengths in the energy-range 11·5–15·7 eV.; (2) charge-exchange between argon ions and alcohol molecules producing monochromatic photons of energy $(I_1 - I_2)$ eV. corresponding to a wave-length of about 2800 Å., I_1 and I_2 being the ionization potentials of argon and alcohol respectively; (3) recombination of argon ions with electrons in the vicinity of the anode to the excited levels of argon atoms.

Soft ultra-violet photons which may liberate secondary electrons from the cathode will arise from (2) and (3). There will be no soft ultra-violet photons, other than those of wave-length 2800 Å., if process (3) did not occur within the time-interval of a major pulse, namely, about a microsecond.

Some workers[3] believe that soft photons do not play any important part in the spread of the discharge. We have shown that this is not so. The present work has led us to the following conclusions: (i) soft ultra-violet photons energetic enough to liberate photo electrons from the counter cathode are produced in the counter due to recombination of argon ions; (ii) ultra-violet photons have a much smaller absorption coefficient in alcohol than is usually assumed; (iii) the photoelectric efficiency of a self-quenching counter is dependent on its over-voltage, a point of considerable interest in the operation of these tubes.

Two brass counters, each 5·5 cm. in active length and 4·3 cm. in diameter, with tungsten anodes 0·2 mm. thick are housed in a specially constructed steel chamber 12 in. in diameter and 9 in. deep. They are supported in position within the chamber with two Wilson seals passing through its steel bottom plate. A second steel plate with a central window 9 cm. in diameter and covered with a polystyrene disk closes the top of the chamber. The two steel plates are screwed together with steel rods and the chamber is made air-tight with 'O' rings pressed between its wall and the two end-plates, while the polystyrene disk is fixed with 'Araldite'. A third Wilson seal also passing through the bottom steel plate carries within the chamber a framework which holds a narrow-band ultra-violet interference filter which was inserted in between the two counters when desired. The filter, type *U* 417, supplied by Messrs. Barr and Stroud, Ltd., of Glasgow, has peak transmission at 2537 Å. and has a band-width (half-peak to half-peak) of 160 Å.

One counter acts as a source of photons and is irradiated by a collimated gamma-ray beam to give a counting rate of about 2,000 c./m. while the other counts 300–400 c./m. The end facing the second counter is closed by an insulating cap carrying a narrow channel 2 cm. long at its centre. The two counters had their anodes on a common axis when facing each other and were adjusted by means of the Wilson seals. The chamber was filled with an argon–alcohol mixture containing 10 per cent alcohol at a total pressure of 10 cm. of mercury.

The pulses from the counters were fed into a coincidence unit, type 1036 *B*, with a resolving time of 1 μsec. and the coincidence pulses were recorded in the scaler, type 200 *A*. The counter voltages were supplied from stabilized power units.

Coincidences were observed with the channel of the source counter directed towards different parts of the second counter with and without the ultra-violet filter between them.

In one set of experiments the over-voltage of the source counter was changed, keeping that on the second counter fixed in its plateau range. In another

Table 1. Over-voltage (Fixed) on the Second Counter, 220 V. Distance between two counters, 5 cm.; inclination between axes of counters, 45°; counter slopes, 0·03 and 0·02 per cent per V.; plateau lengths, 220 and 380 V.

Over-voltage on the source counter (V.)	Coincidences per 10 min. without filter	Coincidences per 10 min. with filter
20	8	Nil
60	18	2
100	408	56
140	486	54
180	548	59

Table 2. Over-voltage (Fixed) on the Source Counter, 180 V.

Over-voltage on the second counter (V.)	Coincidences per 10 min. without filter	Coincidences per 10 min. with filter
20	13	Nil
60	459	5
100	567	8
140	540	45
180	532	51
220	541	62

set the voltage on the source counter was fixed and that on the second counter was changed within its plateau, keeping the channel directed towards its cathode at a fixed angle.

Observations were taken with different distances between the counters. Typical results are given in Tables 1 and 2.

The increase in the number of coincidences in Table 1 with the over-voltage on the source counter is due to greater yield of ultra-violet photons from it with rise in its operating voltage. The increase in the coincidences with the over-voltage on the second counter with filter in Table 2 is, we believe, due to its greater photoelectric efficiency with the rise in the electric field on its counter cathode. The change in the photoelectric efficiency with the electric field on the counter cathode may be due to the 'return' to the cathode of photo-electrons released from it by photons; a phenomenon which has scarcely been studied so far in self-quenching Geiger-Müller counters.

A comparison of the results in Table 2 with filter and without it indicates that the coincidences without filter are mainly due to the photoelectric effect of photons of the source counter falling on the cathode of the second and that photons other than those of wave-length 2537 Å. must be present to account for their greater number. We believe, however, that the hard component of the ultra-violet photons is also causing coincidences by ionization. That photo-ionization is also occurring has been checked by firing the photon beam axially across the second counter and noting the coincidences with and without filter. In the former case there was not a single coincidence in 10 min., whereas in the latter 100–200 coincidences were obtained in the same interval of time.

In other experiments we have shown that ultra-violet photons of long wave-length can travel across a tube 10 cm. long, filled with alcohol at a pressure of 1–3 cm. mercury or even higher. These photons were detected at the end of their journey by a self-quenching Geiger-Müller counter due to their photo-electric effect on its cathode. The ultra-violet radiation was produced by a mercury arc with a quartz window on a side tube. These results are in agreement with our work with counters.

Our results may be of interest also in connexion with the preparation of self-quenching Geiger–Müller counters with a filling of permanent gases[4].

We are grateful for the supply in 1959 under the Colombo Plan of electronic equipment, some of which was used in this work.

Rafi Mohammed Chaudhri
Rahmat Ullah
High Tension and Nuclear Research Laboratory,
Church Road,
Lahore, West Pakistan.

[1] Korff, S. A., "Electron and Nuclear Counters", second ed., 128 (D. Van Nostrand Co., 1955). Chaudhri, R. M., Khan, M. Y., Khawaja, A., and Dar, R., *Nature*, **181**, 1526 (1958).
[2] Huster, E., and Ziegler, E., *Z. Phys.*, **146**, 281 (1956); **149**, 583 (1957). Chaudhri, R. M., Khan, M. Y., and Yunas, M., *Nature*, **179**, 1364 (1957).
[3] Mortier, P., Demuynck, J., and Segaert, O., *Nature*, **181**, 1327 (1958).
[4] Collinson, A. J. L., Demetsopoulos, I. C., Dennis, J. A., and Zarzycki, J. M., *Nature*, **185**, 369 (1960).

Impairment of Strength of Quartz Glass through Wetting by Liquids

In a recent communication[1], Radd and Oertle attributed the impairment of the tensile strength of glass fibre fabrics to a chemical solution process. Recently I have measured the tensile strength of quartz-glass rods immersed in various liquids. The rods, which were supplied by the Amersil Quartz Division of Engelhardt Industries, Inc., were selected for a uniform diameter of 1 mm. and cut to a length of 10 cm. They were annealed to remove residual strains. Three-point bending, using a calibrated spring, was used to apply a maximum stress at the centre, where the rods were scratched before they were broken. Scratches of identical depth were made on the underside of each rod by cutting with a diamond cutting tool that was applied with a constant force. All experiments were performed in a moisture-free atmosphere on previously dried rods. The mean loads at fracture, together with the 95 per cent confidence interval for the liquids water, oleylamine, and *n*-hexadecane, are shown in Table 1. Great care was taken to free the *n*-hexadecane of all polar impurities and the oleylamine of water. The last column shows the probability of the null hypothesis $M_1 - M_2 = 0$ being correct for the means of the two pairs water–oleylamine and oleylamine–*n*-hexadecane, respectively[2].

Table 1

Environment	Mean fracture load (gm.)	Probability of null hypothesis $M_1 - M_2 = 0$
Distilled water	13·3 ± 2·1	$0{\cdot}001 < P < 0{\cdot}005$
Oleylamine	18·8 ± 3·0	$0{\cdot}01 < P < 0{\cdot}025$
n-Hexadecane	24·5 ± 3·8	

In another experiment I measured the time that elapsed before delayed fracture set in when seven quartz-glass rods were immersed in *n*-hexadecane and seven were immersed in oleylamine, all of which were then subjected to the same load, which corresponded to 95 per cent of the mean rapid fracture load measured with oleylamine. The breaking times until fracture are listed in Table 2.

The breaking stress – time relationship apparently results from the gradual penetration into the crack of substances that are adsorbed on the crack wall and lower the interfacial free energy.

Table 2

Environment	Time until fracture (sec.)						
n-Hexadecane	1,326;	2,886;	16,560;	480;	2,127;	11,775;	900
Oleylamine	15;	0;	55;	10;	5;	0;	2

The relative breaking stresses measured by me with different liquids agree well with those obtained by Culf[2], who measured the extension of cone cracks in glass under different liquids. They can best be explained by a mechanism involving a lowering of the interfacial free energy γ, which according to Griffith's formula $\sigma \simeq \sqrt{\frac{E \cdot \gamma}{c}}$ leads to a reduction of the tensile stress σ necessary to propagate a crack of length c in a solid having Young's modulus E. Available data on free energies of immersion[4] indicate that $\gamma_{SO}-\gamma_{SL}$ is largest for water, intermediate for polar organic compounds, and lowest for nonpolar compounds, where γ_{SO} is the free energy of the solid surface in a vacuum and γ_{SL} is the free energy of the solid-liquid interface. The relative order of magnitude of the free energies of immersion agrees well with the order of breaking strengths obtained with different liquids (Table 1). If the strength impairment of glass were exclusively a chemical solution process, the effect of oleylamine, in which quartz is virtually insoluble, on the breaking strength could not be explained. Charles[5] has pointed out the close correspondence between the concepts of failure by stress corrosion and by lowering of surface energy, which are both compatible with the Griffith criterion. By measuring crack propagation in polar systems that are non-solvents for the solids under consideration, the mechanisms can be separated.

K. H. Hiller

California Research Corporation,
P.O. Box 446,
La Habra, California.

[2] Radd, F. J., and Oertle, D. H., *Nature*, **184**, 976 (1959).
[3] Snedecor, G. W., "Statistical Methods" (Iowa State Coll. Press, Ames, Iowa, 1956).
[4] Culf, C. J., *J. Soc. Glass Tech.*, **41**, 157 (1957).
[4] Van Voorhis, J. J., *et al.*, *J. Phys. Chem.*, **61**, 1513 (1957).
[5] Charles, R. J., "Fracture", Proc. Int. Conf. on the Atom, Mech. of Fract., Swampscott, Mass., 225 (John Wiley and Sons, New York, 1959).

RADIOPHYSICS

Effects of Vertical Diffusion of Electrons near the Magnetic Equator

If electrodynamic movements are neglected, the continuity equation for the electron density N at a fixed height h in region F of the ionosphere may be written :

$$\frac{\partial N}{\partial t} = Q - \beta N + D \qquad (1)$$

where Q is the rate of production of electrons, βN is the effective rate of loss due to recombination processes and D is the contribution due to diffusion. If diffusion is considered to be predominantly vertical, the expression of Ferraro[1] reduces to the following form :

$$D = \frac{b}{n} \sin^2 I \left[\frac{\partial^2 N}{\partial h^2} + \frac{3}{2H}\frac{\partial N}{\partial h} + \frac{N}{2H^2}\right] \qquad (2)$$

where b is a constant, I is the dip angle of the Earth's magnetic field, n is the density of neutral particles, and H is the scale height, here assumed constant. It is also assumed that H is the same for the neutral atmosphere as for the ions : if this is not true, the conclusions reached here will remain essentially unchanged, but the values of the constants will be modified.

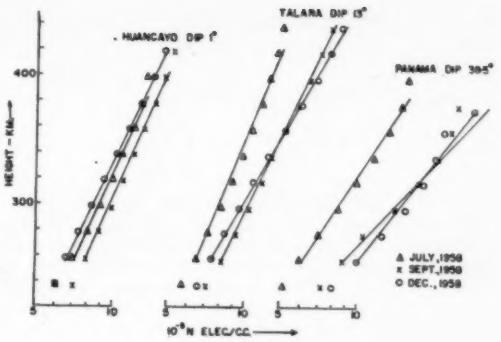


Fig. 1. Mean noon N/h profiles

The effects of diffusion on a parabolic layer have been investigated by a number of authors ; among them Martyn[2] and Ratcliffe, Schmerling, Setty and Thomas[3]. Their conclusions cannot be presented in any simple form, since both the magnitude and sign of the diffusion term depend drastically on the ratio of the parabolic thickness to the scale height.

In the vicinity of the magnetic equator, it is found that the electron density/height profiles are closely exponential in shape below the $F2$ peak during the day. This is illustrated in Fig. 1, where monthly-mean noon profiles are shown for the three stations Huancayo (Peru), Talara (Peru) and Panama (Canal Zone) for summer, equinox and winter months in 1958. A logarithmic scale has been used for N, and it is seen that the profiles are closely exponential at Huancayo (dip 1°) and Talara (dip 13°) for a range of height of 260–400 km. Even at Panama (dip 38·5°), the deviations from this shape are small in the range 260–360 km. It must be noted that, at Panama, there is some distortion in the mean profiles due to large day-to-day variations of height ; profiles for individual days are frequently even closer to exponential form below 360 km.

Representing the profiles by :

$$N = N_0 \exp kh \qquad (3)$$

where N_0 and k are constants, we obtain :

$$D = \frac{b}{n} N \sin^2 I \left[k^2 + \frac{3}{2}\frac{k}{H} + \frac{1}{2H^2}\right] \qquad (4)$$

It is immediately seen that D is always positive and proportional to N. The effect of diffusion is, therefore, always to increase the electron density (below the electron peak). Equation 1 may then be written :

$$\frac{\partial N}{\partial t} = Q - N\left[\beta - \frac{A}{n}\sin^2 I\right] \qquad (5)$$

where A is a constant, simply related to b, k and H.

A few simple deductions follow immediately from equation 5. Assuming quasi-equilibrium near noon for heights below 360 km. :

$$N = \frac{Q}{\beta - \frac{A}{n}\sin^2 I} \tag{6}$$

or, when I is small:

$$N \simeq \frac{Q}{\beta}\left[1 + \frac{A}{\beta n} I^2\right] \tag{7}$$

Now, Q is practically independent of solar zenith angle at heights well above the peak for electron production, and this condition is fulfilled above 260 km. according to Ratcliffe *et al.* It follows that the variation of N with I is approximately parabolic, with a minimum at the dip equator. Croom, Robbins and Thomas[4] have published curves of N against I at various heights obtained from a reduction of ionograms. Their Fig. 1 clearly shows this feature.

The slope of the N/I curve, from equation 7, is given by:

$$\frac{\partial N}{\partial I} = \frac{2QA}{\beta^2 n} I \tag{8}$$

Since $\beta^2 n$ decreases with height more rapidly than Q, the slopes of the N/I curves are expected to increase with height. This feature, also, is shown in Fig. 1 of Croom *et al.* Data from any pair of heights can be used to eliminate the constant A, which is not, at present, well established. At a dip angle of 25°, the curves of Croom *et al.* can then be used to evaluate the scale height for β if the scale heights for Q and n are taken to be roughly equal. For the pairs of curves at 300 and 320, as well as 320 and 340 km., consistent values of about 50 km. are obtained, in good agreement with the value given in Ratcliffe *et al.*

Since it is clear that N must always be positive, an examination of the denominator of equation 6 indicates that the theory presented here may be expected to break down at greater heights and larger values of dip angle. The fact that N/h profiles cease to be exponential away from the dip equator may be considered as one aspect of this theory, which suggests, indeed, that diffusion prevents them from retaining an exponential shape there. Equation 6 also indicates that, at greater heights, this breakdown must occur at smaller values of I. This is evidenced in Fig. 1 of Croom *et al.* by a shift towards the dip equator of the maxima of the N/I curves with increasing height.

It is concluded that quite simple considerations of vertical diffusion account for the major features of the 'geomagnetic anomaly' as presented by Croom *et al.*, and that this anomaly consists of excess ionization, due to diffusion, away from the equator, rather than a deficiency of ionization at the equator.

The work reported here has been sponsored by the U.S.A. National Committee for the International Geophysical Year under Project No. 6.9.

E. R. Schmerling

Ionosphere Research Laboratory,
The Pennsylvania State University,
University Park,
Pennsylvania.

[1] Ferraro, V. C. A., *Terr. Mag. and Atmo. Elect.*, **50**, 215 (1945).
[2] Martyn, D. F., Phys. Soc. Report on Cambridge Ionosphere Conference, 254 (1955).
[3] Ratcliffe, J. A., Schmerling, E. R., Setty, C. S., and Thomas, J. O., *Phil. Trans. Roy. Soc.*, A, **248**, 621 (1956).
[4] Croom, Sheila, Robbins, Audrey, and Thomas, J. O., *Nature*, **184**, 2003 (1959).

GEOPHYSICS

Stress-induced Magnetic Anisotropy of Rocks

Rocks containing 1 or 2 per cent of magnetic minerals are so slightly ferromagnetic that reliable measurements of magnetostriction by the direct observation of changes in dimensions would, at best, be extremely difficult. However, an understanding of the magnetostriction of rocks is very desirable on account of the disagreement which has arisen concerning its possible role in palæomagnetism[1-4]. The purpose of this communication is to report an experiment which shows that the saturation magnetostrictions of rocks are easily measured in terms of stress-induced anisotropy, and that, in the few rocks examined, they have values which would be expected from their known magnetic mineral contents.

Five specimens have been used: two samples of Tasmanian dolerite, two of basalt from Kiama, New South Wales, and one of monchiquite, also from Kiama. In all these rocks the natural (unstressed) anisotropies are very small, and, regardless of any slight alignment of grain elongations, the crystallographic axes of the magnetic grains have been shown to be randomly oriented (by the method described by Stacey[5]). In this case the theoretical treatment of magneto-elastic energy, E_θ, is simple[6]. When a specimen is subjected to an axial stress (measured as positive for a compression) at an angle θ to a strong field, in which it is magnetically saturated, E_θ is given by:

$$E_\theta = \frac{3}{2}\lambda_s \sigma \cos^2\theta \tag{1}$$

where λ_s is the saturation magnetostriction. The torque T_θ exerted on the specimen by the field exceeds the torque T_0 due to its natural anisotropy by an amount:

$$T_\theta(\theta) - T_0(\theta) = -\frac{dE_\theta}{d\theta} = \frac{3}{2}\lambda_s \sigma \sin 2\theta \tag{2}$$

Torque curves $T_\theta(\theta)$ and $T_0(\theta)$ have been measured for the five specimens.

Each specimen was cut and ground to the shape of a cylinder, 21 mm. in diameter by 15 mm. long, with an axial hole 9·5 mm. in diameter. It was compressed between copper washers, 3 mm. thick, and thin lead washers by tightening a copper nut and bolt which were inserted through the axial hole. The load applied was the same in all cases and was controlled by tightening the copper bolt until it was felt to yield. The load was measured by pairs of electrical resistance strain gauges which were stuck on to two of the specimens, making rock load cells. These cells were calibrated in a mechanical load-testing machine, and the stress applied to the specimens by means of the copper bolt was measured as 520 kgm./cm.^{2} ± 10 per cent ($5{\cdot}2 \times 10^8$ dynes/cm.^{2}).

The specimen plus copper bolt was sufficiently small to be suspended on a simple torque-meter, described previously[7]. First the torque $T_0(\theta)$ exerted on the unstressed specimen (plus copper bolt) by a 10·6 kilo-oersted field was measured as a function of the angle θ between the axis of the bolt and the field direction. The torque curve $T_\theta(\theta)$ in the stressed state was then measured in the same way, and afterwards the $T_0(\theta)$ curve was repeated to show

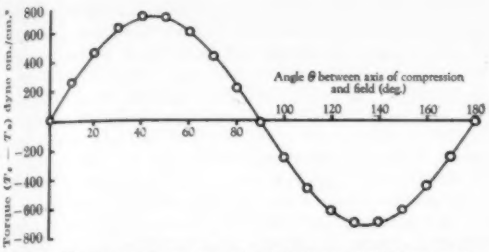


Fig. 1. Torque curve due to a directed stress of 520 kgm./cm.² on a sample of basalt, suspended in a field of 10·6 kilo-oersteds. Circles are experimental points, line is sin 2θ curve

that the application of stress had not produced any permanent anisotropy. Curves of the difference $(T_\theta(\theta) - T_0(\theta))$ were plotted, showing the expected sin 2θ form (2), as in the example in Fig. 1. The values of λ_s determined from $(T_\theta - T_0)$ using equation (2) are given in column 3 of Table 1.

Table 1. Saturation Magnetostrictions of Five Rock Samples

Rock	$(T_\theta - T_0)$ dyne cm./cm.²	(λ_s) exp.	I_s e.m.u./cm.³	(λ_s) calc.
Dolerite	150	$0{\cdot}20 \times 10^{-6}$	4·0	$0{\cdot}2_0 \times 10^{-6}$
	150	$0{\cdot}19 \times 10^{-6}$	4·0	$0{\cdot}2_0 \times 10^{-6}$
Basalt	710	$0{\cdot}91 \times 10^{-6}$	11·1	$0{\cdot}6 \times 10^{-6}$
	750	$0{\cdot}97 \times 10^{-6}$	11·3	$0{\cdot}6 \times 10^{-6}$
Monchiquite	630	$0{\cdot}81 \times 10^{-6}$	9·2	$0{\cdot}5 \times 10^{-6}$

The saturation magnetic moments I_s of the rocks were also measured and are given in column 4 of the table. These values were used to make crude estimates of the expected magnetostrictions $(\lambda_s)_{calc.}$ (column 5) by assuming that magnetostriction is proportional to I_s:

$$\lambda_s = \lambda_{sm}(I_s/I_{sm}) \qquad (3)$$

where λ_{sm} and I_{sm} are values of λ_s and I_s for pure magnetite and are taken as $\lambda_{sm} = 25 \times 10^{-6}$, $I_{sm} = 480$ e.m.u./cm.³. It is reasonable to expect that (3) would be correct for a rock in which the only strongly magnetic mineral is nearly pure magnetite. This is the case with the dolerite specimens, in which 2·0 per cent by volume of the rock is magnetic mineral, approximately half being magnetite with $I_s \sim 400$ e.m.u./cm.³ and half ilmenite, which can be neglected for this purpose. The magnetic minerals in the basalts from Kisma are impure cubic magnetites (L. G. Parry, private communication) for which values of λ_s are not known. However, for the three rock types examined here magnetostriction has the sign and approximate magnitude expected for magnetite-bearing rocks and it is reasonable to take as general the rule that the magnetostriction of a rock may be simply calculated as a weighted sum of the magnetostrictions of its constituent magnetic minerals.

In view of this result, the experiments reported by Stott and Stacey[3,4] show that when an intrinsically isotropic rock is subjected to stress while cooling in a field it acquires thermo-remanent magnetization in a direction deflected away from the field by such an angle that it returns precisely to the field direction when unloaded.

The determination of saturation magnetostrictions of slightly magnetic materials by the method described above could certainly be used, without modification, down to $\lambda_s = 10^{-6}$ and appears to be capable of even further development.

F. D. Stacey

Geophysics Department,
Australian National University,
Canberra.

[1] Graham, J. W., Buddington, A. F., and Balsley, J. R., *J. Geophys. Res.*, **62**, 465 (1957).
[2] Graham, J. W., Buddington, A. F., and Balsley, J. R., *Nature*, **183**, 1318 (1959).
[3] Stott, P. M., and Stacey, F D., *Nature*, **183**, 384 (1959).
[4] Stott, P. M., and Stacey, F. D., *J. Geophys. Res.* (in the press).
[5] Stacey, F. D., *J. Geophys. Res.* (in the press).
[6] Lee, E. W., "Rep. on Prog. in Phys.", **18**, 184 (1955).
[7] Stacey, F. D., *Austral. J. Phys.*, **13**, 196 (1960).

GEOLOGY

Charnockite in the Making

Extensive quarrying is being done on the hill slopes west of Kabbal (12° 30′ N., 77° 18′ E., situated about 40 miles south-south-west of Bangalore), and so fresh surfaces were available for examination. Peninsular gneiss is the prevailing rock of this region. It is thinly foliated and often highly contorted. The gneiss is generally biotitic; but there are hornblendic layers and streaks.

In the middle of the light-coloured banded exposures of gneiss there are small irregular or elongated patches of coarse-grained, greasy, brownish-green rock (Fig. 1). The disposition of these patches bears no relation to the foliation direction of the gneiss, and often runs athwart it. Though the fabric has been affected because of coarser crystallization, it is remarkable that in many of these patches the banding of the gneiss can still be recognized to be passing through them. Crystals of hypersthene exhibiting schiller lustre have been developed in these coarse patches.

From the geological map of Mysore State, it can be seen that the main mass of charnockite occurring in the Biligirirangan Hills and eastwards branches into narrow finger-like projections in the Halagur–Satnur region north of the River Cauvery, an area which was formerly mapped as Closepet granite but which is now known to be composed mainly of Peninsular gneiss. Farther northwards, the charnockites are found in patches of varying sizes, and even these isolated occurrences completely disappear near about lat. 12° 30′ N. Kabbal is situated on one such fringe of the huge charnockite massif which includes the Biligirirangan Hills and the Nilgiri Mountains.

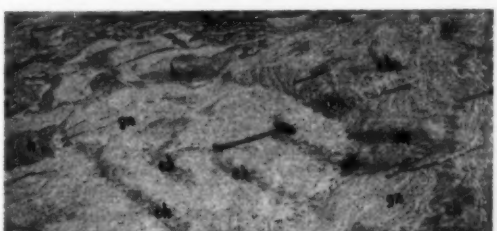


Fig. 1. Photograph of a quarry face showing charnockite patches (*ch*) in Peninsular gneiss (*gn*). The dark areas in the top left hand of the picture are composed of hornblendic inclusions (*h*) of varying sizes

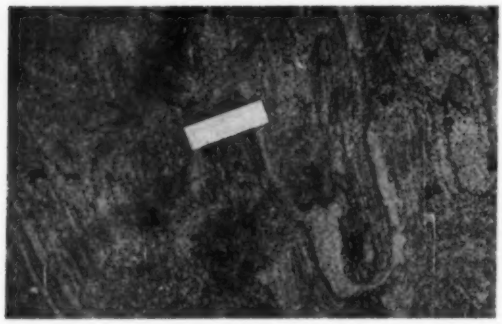


Fig. 2. A close-up photograph showing parts of contorted Peninsular gneiss (*gn*) becoming converted into charnockite (*ch*). The coarse crystallization has resulted in the partial obliteration of the foliation of the gneiss. The protractor-scale is 6 in. long

Figs. 1 and 2 clearly show that portions of the gneisses are becoming converted into charnockites. When recrystallization has advanced, the gneissic foliation is destroyed ; but in the intermediate stages the banding can be traced through the patches getting charnockitized (Fig. 2). In Kabbal, we are apparently on the rim of a charnockitization front where it is possible to have visual demonstration of the successive stages in the transformation of a gneiss to a coarse-grained rock.

The changes can also be followed in thin sections of these rocks. Flakes of biotite in parallel alignment characterize the gneiss. The basic patches are composed mainly of green amphiboles with occasional biotites. When subjected to transformation, a light-green diopside develops from the hornblendes. In the charnockitic patches, coarse hypersthenes with the characteristic pink to green pleochroism have been formed. The amphiboles are brownish-green in colour, and the biotites when present are foxy-red.

C. S. Pichamuthu

Department of Geology,
University of Malaya,
Kuala Lumpur.

CRYSTALLOGRAPHY

Super-Cell Structure of Semiconductors

The structures of many compounds and alloys have been shown to be essentially super-lattices on a few basic lattices. Interest in the diamond structure in particular has been stimulated recently by the technological importance of semiconductors. The best known semiconductors—germanium and silicon—have the diamond structure and many semiconducting compounds of interest have the closely related structures of zinc blende and chalcopyrite. Some work[1] has been done recently in an attempt to list the possible super-lattices of the cubic lattices, but the diamond structure has not yet been considered. The aim of this communication is to introduce a new line of attack on this problem of super-lattices.

The diamond structure consists of two interpenetrant face-centred cubic sub-lattices symmetrically spaced. The zinc blende lattice can be thought of as a super-lattice of the diamond structure in which each of these sub-lattices is occupied by a different atomic species. If the distribution of atoms in zinc blende could be randomized the structure would become a 'defect' diamond structure. (For a discussion of the term 'defect' see ref. 2.) Any adamantine material may in like manner be described as a super-lattice on the diamond structure and its unit cell will be related to the unit cell of diamond. Similar families of compounds can be found based on other basic lattices. I propose to call possible unit cells of super-lattices based on a given lattice 'super-cells' of that lattice, and to illustrate the concept here with reference to the adamantine super-cells. In practice the formation of a super-lattice often leads to a distortion of the original lattice. Since, however, this is often slight I shall neglect it in this treatment and assume that pseudo-cubic symmetry is accurately maintained when a super-lattice is formed. Thus I shall assume in discussing the adamantine super-cells that the atomic sites available are exactly those of a diamond structure.

Table 1 lists the simpler adamantine super-cells. The nomenclature chosen (*C* (cubic), *T* (tetragonal) and *O* (orthorhombic)) denotes the external symmetry of the super-cell in question—which is also the highest symmetry class possible for a substance with this as its unit cell. Super-cells within each of these main groups are numbered in order of increasing size. For simplicity certain less-symmetrical super-cells will not be discussed.

At first sight it might be thought that all super-cells would be built up of simple unit cells and thus that the super-cell dimensions would be simple multiples of the *C*1 cell. This is not so, because the conventional unit cell of diamond is not primitive. Thus the *T*1 super-cell may be derived from the normal unit cell (here called the *C*1 cell) by the standard transformation of face-centred tetragonal to body-centred tetragonal. This cell is still not

Table 1. Simpler Adamantine Super-cells

Crystal class	Cell label	Dimensions	No. of sites	Cell label	Dimensions	No. of sites
Cubic	*C*1	1 1 1	8	*C*4	4 4 4	512
	*C*2	2 2 2	64	*C*5	5 5 5	1,000
	*C*3	3 3 3	216	*C*6	6 6 6	1,728
Tetragonal	*T*1	$1/\sqrt{2}$ $1/\sqrt{2}$ 1	4	*T*19	$1/\sqrt{2}$ $1/\sqrt{2}$ 11	44
	*T*2	$1/\sqrt{2}$ $1/\sqrt{2}$ 2	8	*T*20	$1/\sqrt{2}$ $1/\sqrt{2}$ 12	48
	*T*3	$1/\sqrt{2}$ $1/\sqrt{2}$ 3	12	*T*21	1 1 6	48
	*T*4	$1/\sqrt{2}$ $1/\sqrt{2}$ 4	16	*T*22	$\sqrt{2}$ $\sqrt{2}$ 3	48
	*T*5	1 1 2	16	*T*23	$1/\sqrt{2}$ $1/\sqrt{2}$ 13	52
	*T*6	$\sqrt{2}$ $\sqrt{2}$ 1	16	*T*24	$1/\sqrt{2}$ $1/\sqrt{2}$ 14	56
	*T*7	$1/\sqrt{2}$ $1/\sqrt{2}$ 5	20	*T*25	1 1 7	56
	*T*8	$1/\sqrt{2}$ $1/\sqrt{2}$ 6	24	*T*26	$1/\sqrt{2}$ $1/\sqrt{2}$ 15	60
	*T*9	1 1 3	24	*T*27	$1/\sqrt{2}$ $1/\sqrt{2}$ 16	64
	*T*10	$1/\sqrt{2}$ $1/\sqrt{2}$ 7	28	*T*28	1 1 8	64
	*T*11	$1/\sqrt{2}$ $1/\sqrt{2}$ 8	32	*T*29	$\sqrt{2}$ $\sqrt{2}$ 4	64
	*T*12	1 1 4	32	*T*30	$2\sqrt{2}$ $2\sqrt{2}$ 1	64
	*T*13	$\sqrt{2}$ $\sqrt{2}$ 2	32	*T*31	$1/\sqrt{2}$ $1/\sqrt{2}$ 17	68
	*T*14	2 2 1	32	*T*32	$1/\sqrt{2}$ $1/\sqrt{2}$ 18	72
	*T*15	$1/\sqrt{2}$ $1/\sqrt{2}$ 9	36	*T*33	1 1 9	72
	*T*16	$3/\sqrt{2}$ $3/\sqrt{2}$ 1	36	*T*34	$3/\sqrt{2}$ $3/\sqrt{2}$ 2	72
	*T*17	$1/\sqrt{2}$ $1/\sqrt{2}$ 10	40	*T*35	3 3 1	72
	*T*18	1 1 5	40			
Orthorhombic	*O*1	$1/\sqrt{2}$ $\sqrt{2}$ 1	8	*O*16	$1/\sqrt{2}$ $9/\sqrt{2}$ 1	36
	*O*2	$1/\sqrt{2}$ $3/\sqrt{2}$ 1	12	*O*17	$1/\sqrt{2}$ $\sqrt{2}$ 5	40
	*O*3	$1/\sqrt{2}$ $\sqrt{2}$ 2	16	*O*18	$1/\sqrt{2}$ $5/\sqrt{2}$ 2	40
	*O*4	$1/\sqrt{2}$ $2\sqrt{2}$ 1	16	*O*19	$1/\sqrt{2}$ $5\sqrt{2}$ 1	40
	*O*5	$1/\sqrt{2}$ $5/\sqrt{2}$ 1	20	*O*20	$\sqrt{2}$ $5/\sqrt{2}$ 1	40
	*O*6	$1/\sqrt{2}$ $\sqrt{2}$ 3	24	*O*21	$1/\sqrt{2}$ $11/\sqrt{2}$ 1	44
	*O*7	$1/\sqrt{2}$ $3/\sqrt{2}$ 2	24	*O*22	$1/\sqrt{2}$ $\sqrt{2}$ 6	48
	*O*8	$1/\sqrt{2}$ $3\sqrt{2}$ 1	24	*O*23	$1/\sqrt{2}$ $3/\sqrt{2}$ 4	48
	*O*9	$\sqrt{2}$ $3/\sqrt{2}$ 1	24	*O*24	$1/\sqrt{2}$ $2\sqrt{2}$ 3	48
	*O*10	$1/\sqrt{2}$ $7/\sqrt{2}$ 1	28	*O*25	$1/\sqrt{2}$ $3\sqrt{2}$ 2	48
	*O*11	$1/\sqrt{2}$ $\sqrt{2}$ 4	32	*O*26	$1/\sqrt{2}$ $6\sqrt{2}$ 1	48
	*O*12	$1/\sqrt{2}$ $2\sqrt{2}$ 2	32	*O*27	1 2 3	48
	*O*13	$1/\sqrt{2}$ $4\sqrt{2}$ 1	32	*O*28	$\sqrt{2}$ $3/\sqrt{2}$ 2	48
	*O*14	$\sqrt{2}$ $2\sqrt{2}$ 1	32	*O*29	$\sqrt{2}$ $3\sqrt{2}$ 1	48
	*O*15	$1/\sqrt{2}$ $3/\sqrt{2}$ 3	36	*O*30	$3/\sqrt{2}$ $2\sqrt{2}$ 1	48

The super-cell dimensions are given in units of the simple unit cell parameter '*a*'.

Table 2. Some Typical Adamantine Compounds listed by Super-cells

Super-cell	Adamantine compound
*C*1	C (diamond), Si, Ge, Sn (grey) ZnS (blende) and more than 30 analogues including the III–V, II–VI, and certain I–VII compounds $CdIn_2\square$ Se_4 and $Cu_2Hg\square I_4$
*C*2	Cu_3SbS_3 (tetrahedrite), Cu_3SbS_4 and related compounds
*T*5	$CuFeS_2$ (chalcopyrite) and its analogues Cu_2 Fe SnS_4 (stannite) Many II $III_2\square VI_4$ compounds
*T*16	Holmes structure for In_2Te_3 (not strictly adamantine) (see ref. 7)
*O*2	Woolley and Pamplin's structure for $In_2\square Te_3$
*O*3	$Ga_2\square Hg_2Te_5$ and $In_2\square Hg_2Te_4$ (possibly)

$\square$ is the symbol for a vacant lattice site.

primitive—the primitive cell of diamond is in fact a rhombohedral one and so not listed in Table 1.

Table 2 shows some typical adamantine materials listed by means of their super-cells. A fuller discussion of the inter-relationship of the adamantine compounds can be found in ref. 3.

A general formula for an adamantine compound can be written thus :

$$A_aB_bC_c \ldots X_xY_yZ_z \ldots$$

where $a,b,c, \ldots x,y,z, \ldots$ are the relative numbers of $A,B,C, \ldots X,Y,Z, \ldots$ atoms in the compound. The elements $A,B,C, \ldots$ come from any of the first four B sub-groups of the periodic table, while $X,Y,Z, \ldots$ come from the remaining B sub-groups (omitting, of course, the rare gases). The formula is valid as a candidate for the diamond structure provided that there are on average four valence electrons per site. This requires that :

$$\frac{\Sigma_i n_i v_i}{\Sigma_i n_i} = 4$$

where n_i is the number of atoms of the ith kind, with v_i electrons in its outer shell. Vacant sites must be counted, and for these v_i is zero. This provides a necessary, but not sufficient, condition for the existence of an adamantine material. It is readily seen that the Mooser and Pearson rule[4] is satisfied, and so all adamantine materials will be expected to be semiconductors.

I have calculated[3] the various classes of intensity of X-ray reflexions which are to be expected from a *C*1 and a *C*2 super-cell in which all the atomic sites are assumed different. The results can readily be applied in the analysis of any new super-lattice which may be described on either of these unit cells. The *C*2 super-cell is especially interesting because it includes the smaller super-cells *C*1, *T*1, *T*2, *T*5, *T*6, *T*13, *T*14, *O*1 and *O*3, and thus embraces most of the common adamantine compounds.

The study of solid solutions between compounds of the zinc blende type has already yielded several new examples of super-lattices. Super-cells may be used to predict compositions at which ordering may occur. Ordering will be possible on a given super-cell only if the number of sites available in that super-cell is correlated with the composition of the alloy. Consider, for example, alloys of two zinc blende compounds MX and NY. A general alloy may be written :

$$M_xN_{1-x}X_xY_{1-x}$$

Ordering on a *C*1 cell is possible for $x = \frac{1}{4}$, $\frac{1}{2}$ or $\frac{3}{4}$. Ordering on a *T*3 or *O*2 cell is possible for $x = \frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$ or $\frac{3}{4}$. Also on a *T*4, *T*5, *T*6, *O*3 or *O*4 cell for $x = \frac{1}{4}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{1}{2}$, $\frac{3}{5}$, $\frac{2}{3}$ or $\frac{3}{4}$. Thus the most likely compositions for ordering are $x = \frac{1}{2}$, $\frac{1}{4}$ or $\frac{3}{4}$, while $x = \frac{1}{5}$ (requiring, for example, a *T*7 or *O*5 super-cell) is much less likely to be an ordering composition. If ordering is suspected at a particular composition then a consideration of the possible super-cells enables one to predict the pattern of super-lattice lines which will occur. For example, if $x = \frac{1}{4}$ is thought to be an ordered phase, then the super-lattice powder lines should be indexed at first on a threefold cubic cell (*C*3). From the absences which occur it should be possible to decide between *T*3 and *O*2.

Another use of super-cells is in the examination of alternative structures. Chalcopyrite, $CuFeS_2$, was originally assigned a tetragonal structure based on a distorted *C*1 cell[5]. Fifteen years later Pauling and Brockway[6] showed that the now generally accepted structure based on a *T*5 super-cell gave better agreement with the X-ray data. Many of the recently discovered ordered adamantine materials may perhaps need a similar revision. A systematic examination of the possible adamantine super-lattices is a desirable starting point for a critical survey of the known materials as well as for the prediction of new ones.

Super-cells should also prove useful in discussing the effects of ordering on the properties of a material, because changes in shape of the Brillouin zone due to ordering may be deduced from X-ray intensity calculations.

A fuller discussion including details of the X-ray intensity calculations will be published elsewhere in due course.

I wish to thank Dr. J. C. Woolley and Dr. S. Wallwork for helpful discussions.

B. R. Pamplin*

Physics Department,
University of Nottingham.

* Present address : Department of Applied Physics, Science Laboratories, University of Durham, Durham City.

[1] Smirnova, N. L., *Soviet Phys. Cryst.*, **3**, 232, 362 (1958); **4**, 10, 17 (1960).
[2] Strock, L. W., *Z. Krist.*, **93**, 285 (1936).
[3] Pamplin, B. R., Ph.D. Thesis, Nottingham (1960).
[4] Mooser, E., and Pearson, W. B., *J. Electronics*, **1**, 629 (1956).
[5] Burdick, C. L., and Ellis, J. H., *J. Amer. Chem. Soc.*, **39**, 2518 (1917).
[6] Pauling, L., and Brockway, L. D., *Z. Krist.*, **82**, 188 (1932).
[7] Woolley, J. C., Pamplin, B. R., and Holmes, P. J., *J. Less Com. Met.*, **1**, 362 (1959).

METALLURGY

Determination of Silver in Lead Concentrates by Atomic Absorption Spectroscopy

The fire assay method is used universally for the determination of silver in ores and concentrator products. This method, which is capable of very high precision, is subject to a loss of silver during cupellation, and corrections for this loss, if made, must be on an empirical basis depending on the conditions of cupellation[1–3]. Walsh[4] showed that atomic absorption spectroscopy offered possibilities as an absolute spectrochemical method freed from the necessity of using chemically analysed standards or synthetic samples the composition of which approximated that of the unknown. Several papers[5–7] on the application of atomic absorption spectroscopy to

the determination of cations in solution have been published. These papers showed that, in general, the atomic absorption technique was free from inter-element effects and required the minimum amount of manipulation. Lockyer and Hames[8] directed attention to the possibility of determining the noble metals by atomic absorption spectroscopy and quoted a limit of detectability of 0·1 p.p.m. for silver.

We have studied the application of this technique to the determination of silver in the lead–silver–zinc ores and concentrator products at the Zinc Corporation Ltd., Broken Hill, Australia. Special emphasis has been placed on the determination of silver in lead sulphide concentrates containing approximately 550 p.p.m. (18·0 oz. per ton) silver.

The apparatus used was basically the same as that described by Box and Walsh[9]. Initially an EEL flame photometer burner giving a 2·5-cm. flame path was used. In order to obtain satisfactory absorption readings it was necessary to use silver concentrations of between 10 and 15 p.p.m. This meant that the silver content of 1 gm. of lead concentrate had to be taken into solution in a final volume of 50·0 ml.

Lead at the concentration of 20,000 p.p.m. was shown to have no effect on the absorption due to silver. It was therefore decided to try to eliminate completely all separations.

A number of unsuccessful attempts were made to devise a method based on complete solution of all components in the sample. Techniques which involved the formation of lead sulphate resulted in a loss of silver by adsorption.

The method finally selected was based on the solution of the lead concentrate in concentrated hydrochloric acid, measurement of atomic absorption being made in a 25 per cent v/v hydrochloric acid, 3 per cent v/v nitric acid solution. The standards used were solutions of pure silver in 25 per cent v/v hydrochloric acid run concurrently with each batch of test samples.

Trouble from two sources was experienced when working at these high acid concentrations and with solutions saturated with lead chloride. The stainless steel inlet capillary of the EEL atomizer corroded rapidly, and at the same time lead chloride was precipitated in it. Substitution of a glass inlet capillary eliminated the trouble due to corrosion. To eliminate the precipitation of lead salts in the capillary it was necessary to adjust the conditions so that the final analysis solution, while having a silver concentration of 10–15 p.p.m., was unsaturated with lead chloride.

Table 1 shows a comparison of the silver results obtained by the fire assay and atomic absorption methods on five samples of lead concentrate. Each atomic absorption run was made on a different day. The fire assay results are the average of four determinations and are uncorrected for silver lost during cupellation.

Table 1. THE SILVER CONTENT (OZ./TON) OF LEAD CONCENTRATES

Sample No.	Atomic absorption Run					Mean	Fire assay
	1 (*a*)	2 (*a*)	3 (*b*)	4 (*b*)	5 (*b*)		
1	18·25	18·23	17·98	17·90	17·90	18·05	17·35
2	16·59	16·73	16·58	16·45	16·55	16·58	16·25
3	17·08	17·03	16·98	16·55	16·70	16·87	16·60
4	17·68	17·84	17·69	17·50	18·05	17·75	17·30
5	17·62	17·62	17·49	16·90	17·60	17·45	16·70

a, Analyst *A*; *b*, analyst *B*.

The standard deviation of the atomic absorption results is 1·14 per cent relative. They indicate that atomic absorption spectroscopy offers a rapid and precise means of determining silver in lead concentrates, giving results approximately 0·5 oz. per ton higher than the uncorrected fire assay result at this level.

A more detailed account of this work will be submitted to the Institution of Mining and Metallurgy and the Australasian Institute of Mining and Metallurgy.

B. S. RAWLING
M. C. GREAVES

The Zinc Corporation, Ltd.,
Broken Hill,
New South Wales.

M. D. AMOS

Sulphide Corporation Pty., Ltd.,
Boolaroo,
New South Wales.

[1] King, J. T., Univ. Toronto, Bull. No. 147 (1934).
[2] Guerin, B. D., *Proc. Aust. Inst. Min. Met.*, No. 182 (1) (1957).
[3] Faye, G. H., and Inman, W. R., *Anal. Chem.*, **31**, 1072 (1959).
[4] Walsh, A., *Spectrochim. Acta*, **7**, 108 (1956).
[5] Allan, J. E., *Analyst*, **83**, 466 (1958).
[6] David, D. J., *Analyst*, **83**, 655 (1958).
[7] Gidley, J. A. F., and Jones, J. T., *Analyst*, **85**, 249 (1960).
[8] Lockyer, R., and Hames, G. E., *Analyst*, **84**, 385 (1959).
[9] Box, G. F., and Walsh, A., *Spectrochim. Acta*, **16**, 255 (1960).

Cathodic Cleaning of Metals before High-Temperature Oxidation

SINCE metallic oxidation is a surface phenomenon, the preparation of the surface prior to the oxidation experiment is very important. If the method of preparation produces a thin film of oxide or another compound on the surface, the subsequent oxidation may be affected. Thus, Vernon, Akeroyd and Stroud[1] found that the rate of oxidation of zinc below 225° C. was different for abraded, etched or electrolytically polished surfaces. For fundamental work, the ideal is to commence the oxidation with a film-free surface. This was done in the case of iron by Davies, Evans and Agar[2]. The iron was reduced in hydrogen at 480° C., and after this gas had been removed by evacuation, oxygen was introduced. However, it is not possible to carry out this procedure with all metals. Thus the oxide of tin cannot be reduced by hydrogen below the melting point of the metal. The oxidation of solid tin cannot therefore be carried out on an initially film-free surface.

When this is not possible, a method of preparation must be found which is relatively easy to carry out and which also gives reproducible results. One such method is that of cathodic cleaning, with sodium carbonate as an electrolyte, and this has been used in the case of tin. The advantages of the method are: (1) traces of grease are mechanically removed by the hydrogen produced; (2) any oxide film on the surface is reduced to the metallic state. When the specimen is then taken out of the solution, washed and dried, a new oxide film forms on the surface when it is exposed to air. It is reasonable to assume that, provided the specimens have been kept in a desiccator, the thickness of this film is the same each time. Hence the oxidation experiment can be carried out on a surface carrying a thin oxide film of constant thickness.

However, experiments on tin of 99·9999 per cent purity in this laboratory have shown that the mechanism is more complicated than formation in air of a simple film, and can give misleading results. The tin specimen, 5 cm. × 1·6 cm. × 0·01 in. thick, was made the cathode in a 0·1 *M* solution of sodium carbonate with a platinum gauze as anode. A current of 80 m.amp. was supplied from a 12-V. battery for a total time of 14 min. (7 min. each side of specimen facing the anode). The specimen was removed with the current still on, washed with water, then with alcohol and allowed to dry. Such a specimen oxidized at 200° C. for 4 hr. remained bright, whereas an untreated specimen showed mauve interference colours. It is apparent that a film, which interferes with the subsequent oxidation, forms on the tin as a result of the cathodic treatment. The thickness of this film can be determined electrometrically, using a de-aerated solution of 0·005 *M* potassium chromate in the apparatus described by Mills and Evans[3]. The potential of the specimen (cathode) versus a silver–silver chloride reference electrode is measured periodically until the end-point is reached, that is, when the potential changes from that due to oxide reduction to that corresponding to evolution of hydrogen. The number of millicoulombs required for the reduction of the oxide can be taken as a measure of film thickness. The film thickness calculated on this basis is given in Table 1 for specimens oxidized at 200° C. for various times, together with the interference colour.

Table 1. Millicoulombs required for Reduction of Film

Time (hr.)	Before treatment	After treatment
1	11 (no interference colour)	4·4 (no interference colour)
2	19 (yellow)	5·9 ,,
3	23·5 (light brown)	7·3 ,,
4	27·5 (mauve)	10·7 ,,

The film thickness on the untreated specimen after 1 hr. at 200° C. is slightly greater than after 4 hr. of oxidation for the treated specimen.

The film thickness before and after cathodic treatment can also be determined electrometrically. It was found to correspond to 3·47 millicoulombs before treatment and to 2·0 millicoulombs after treatment. Thus the thinner film produced as a result of the cathodic treatment has a much greater influence on the subsequent oxidation than the original film, reducing the rate of oxidation by about one-third. It is obvious that the two films are different, and that cathodic treatment of tin before the high-temperature oxidation of the metal gives results which are not characteristic of the metal itself.

It is possible that this applies to the other metals as well. Therefore, the possible effect of cathodic cleaning on the metal should first of all be investigated, in order to avoid producing misleading results in the subsequent oxidation experiments. In the case of tin, the formation of the resistant film during cathodic treatment is dependent on time of treatment, applied voltage and nature of electrolyte.

D. Eurof Davies
S. N. Shah

Department of Metallurgy,
University College,
Singleton Park,
Swansea.

[1] Vernon, W. H. J., Akeroyd, E. I., and Stroud, E. G., *J. Inst. Metals*, **65**, 301 (1939).
[2] Davies, D. E., Evans, U. R., and Agar, J. N., *Proc. Roy. Soc.*, A., **225**, 443 (1954).
[3] Mills, T., and Evans, U. R., *J. Chem. Soc.*, 2182 (1956).

CHEMISTRY

Phase Diagram of the System Vanadium Pentoxide - Boron Trioxide

In a previous communication I reported on the investigation of the system vanadium pentoxide–phosphorus pentoxide[1]. A similar method has been applied in the examination of the system vanadium pentoxide–boron trioxide. The present report describes the liquidus curve of the system vanadium pentoxide–boron trioxide, together with the results of X-ray investigations of the fine structure. The liquidus curve was established by a special differential thermoanalytical apparatus described in detail in a former communication[2]. The heating curves of five samples are presented in Fig. 1. The composition of these samples was as follows—vanadium pentoxide + boron trioxide, percentages by weight: (1) 95 + 5; (2) 90 + 10; (3) 85 + 15; (4) 70 + 30; (5) 55 + 45.

Apart from the melting point, no other maxima indicating conversion or eutectics appear in the heating curves. The melting point decreases with the rise of content of boron trioxide.

X-ray investigations of fine structure were carried out by the Debye–Scherrer method. The structure of eight samples of various composition was examined. The composition of these samples was as follows—vanadium pentoxide + boron trioxide: 95 + 5; 90 + 10; 80 + 20; 65 + 35; 55 + 45; 50 + 50; 45 + 55; 35 + 65.

The boron trioxide used in preparing these samples was crystallized by a method similar to that applied in the heat treatment of the samples. The lines of the powder diagram, established for the crystals of the product obtained in this way, and also the lines of vanadium pentoxide[3], were found in the powder diagrams of all samples examined. Apart from the lines of the two types of crystals mentioned, no

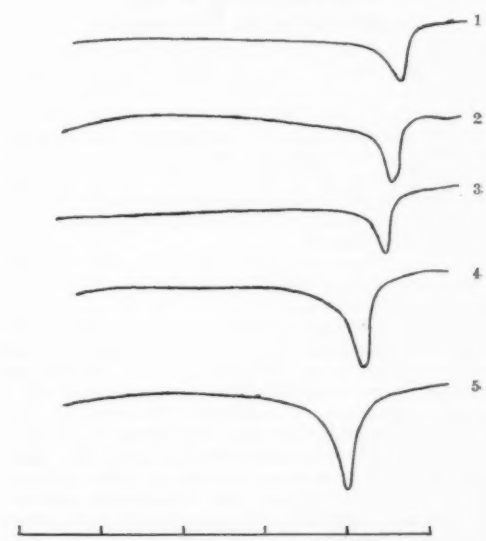


Fig. 1

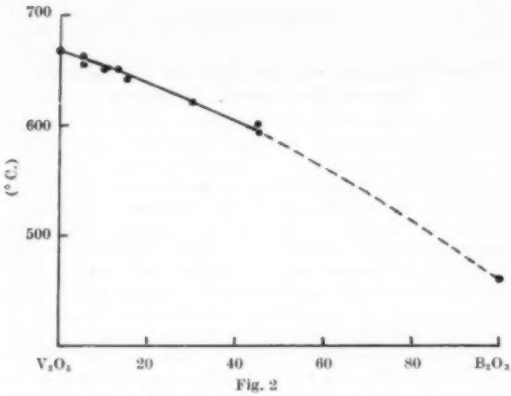


Fig. 2

other interference lines indicating the presence of a third phase were observed.

As the presence of boron trioxide can be detected even in samples containing only 5 per cent of the compound, and as in the sample containing 65 per cent boron trioxide, apart from this compound, only vanadium pentoxide can be detected, the system vanadium pentoxide – boron trioxide cannot be regarded as a eutectic system.

Fig. 2 shows the phase diagram plotted on the basis of the heating curves revealed in Fig. 1, and of the results of the X-ray investigations of fine structure.

B. Nádor

Research Institute for Heavy Chemical Industries, Veszprém, Hungary.

[1] Nádor, B., *Magyar Kém. Foly.*, **65**, 443 (1959).
[2] Nádor, B., *Magyar Kém. Foly.*, **65**, 165 (1959).
[3] Hanawalt, J. D., Rinn, H. W., and Frevel, L. K., *Indust. Eng. Chem., Anal. Ed.*, **10**, 510 (1938).

True Reactivity of the Organocadmium Compounds

While studying the chemistry of the organocadmium compounds, evidence was found making necessary a revision of accepted views regarding their reactivity and indicating that a 'salt effect' plays a critically important part as a catalyst in their reactions. Organocadmium compounds are generally considered to be very reactive with acid chlorides, but practically inert towards aldehydes and ketones[1], thus making possible the important 'organocadmium synthesis' of ketones[1,2].

Although twenty-four years have elapsed since the discovery of this synthesis by H. Gilman, there is no record in the literature of any attempt to use isolated, pure organocadmium compounds to effect the ketone synthesis. Without any exception, the *in situ* reaction mixtures, as obtained by the metathetical reaction of the organomagnesium compounds with cadmium salts, have been used. Therefore, I tried to repeat the acetophenone synthesis of Gilman and Nelson[1] with the difference that pure dimethylcadmium[3] was used instead of the *in situ* reaction. The surprising result was that benzoyl chloride did not form acetophenone with pure distilled dimethylcadmium. (Benzene or ether solution, reaction time 2 hr. at 40°.) 92 per cent of the benzoyl chloride remained unattacked as shown by saponification to benzoic acid. Moreover, under similar conditions, only slight reactivity was observed between benzoyl chloride and distilled diethylcadmium, dibutylcadmium and recrystallized (free from magnesium salt) diphenylcadmium, respectively. When distilled diethylcadmium was treated with acetyl chloride (benzene solution, reaction time 20 min. at 28°), 79 per cent of the diethylcadmium remained unchanged.

In all the recorded cases in the literature, mixtures of the organocadmium compounds and the magnesium salts were used to effect the ketone synthesis; hence my negative findings suggest that in Gilman's original experiments[1] as well as in the hundreds of other ketone syntheses described with the use of organocadmium compounds, a hitherto unrecognized 'salt effect' exerted an unintentional, and in many cases indispensable, activating effect. This salt effect could have been caused by the magnesium salts generated in the usual preparation of the organocadmium compounds:

$$2R\mathrm{Mg}X + \mathrm{Cd}X_2 = \mathrm{Cd}R_2 + 2\mathrm{Mg}X_2$$

The activation hypothesis was supported by the finding that benzoyl chloride produced acetophenone in 74 per cent yield on treatment with distilled dimethylcadmium in the presence of one mole of magnesium bromide. Furthermore, diethylcadmium, dibutylcadmium and diphenylcadmium reacted with benzoyl chloride in the presence of magnesium bromide and magnesium chloride, respectively, giving the corresponding ketones in yields of 60–80 per cent (conditions the same as before). The reaction of acetyl chloride (2 mol.) with distilled diethylcadmium (1 mol.) was complete (97 per cent) when two moles of magnesium bromide etherate were present (benzene solution, 20 min. at 28°). With a longer reaction time (3 hr.), this last reaction goes to completion even in the absence of magnesium salts. In contrast, using less reactive organocadmium compounds, the magnesium salts influence not only the velocity but also the direction of the reaction. Thus, an enforced reaction of benzoyl chloride with dimethylcadmium (5 hr. at 82° in benzene) resulted in a complex mixture of products, with only 20 per cent of acetophenone.

The salt effect influences the reactivity of aldehydes also: benzaldehyde showed only 19 per cent conversion with distilled diethylcadmium in ethyl ether (100 hr. at 25°), but 86 per cent conversion (into phenyl-ethyl-carbinol) in 1 hr. using a diethylcadmium solution prepared from ethylmagnesium bromide and cadmium chloride. These results explain the observations of Gilman[1] with regard to the relative reactivities of aldehydes and acid chlorides with organocadmium compounds; salt-free diethylcadmium was employed in the experiment with benzaldehyde, but even after five months the reaction was incomplete; an *in situ* mixture of the organocadmium compounds and magnesium halides was used in the ketone syntheses.

The elucidation of the difference between the reactivity of the genuine organocadmium compounds and the *in situ* mixtures containing magnesium salts means that we should differentiate between organocadmium chemistry, as at present known, and the chemistry of the genuine organocadmium compounds, which still remains to be studied. The reaction of tertiary alkylhalogenides and organocadmium compounds, as my preliminary experiments indicate, are subject to a catalysis by magnesium salts

also. Therefore, the re-evaluation of the results of J. Cason and R. J. Fessenden[4] seems to be desirable.

William G. Dauben and John W. Collette[5] discussed an abnormal organocadmium reaction, proposing a mechanism for the reaction of arylcadmium compounds with acid chlorides in which an internal Lewis-acid type intermediate of the class of the acylonium salts was postulated. Neither this hypothesis nor other speculations regarding the reaction mechanism or organocadmium reactions[6] considered the catalytic role of magnesium salts in the ketone synthesis although invariably present. Cason and Reist[7] suggested, without any experimental proof, that among others perhaps the magnesium salts could influence the reaction of alkylcadmiums with succinyl dichloride. They supposed that the presence of magnesium salts promotes the side-reaction leading to esters, instead of the normally expected ketones. This assumption contrasts with all of our experimental findings, indicating that magnesium salts promote the formation of ketones, thus diminishing the side reaction.

The recognition of this activation effect opens the way to a planned regulation of the reactivity of organocadmium compounds. It is possible to activate an organocadmium compound in a preselected degree, depending on the type of salt employed. H. Gilman[1] tried unsuccessfully to obtain α-keto esters by the reaction of ethyl chloro-oxalate with diethylcadmium:

$$CdR_2 + 2ClCO \cdot COOC_2H_5 = 2RCO \cdot COOC_2H_5 + CdCl_2$$

I tried the same reaction (with R—CH_3 or n-C_4H_9) with lithium bromide as the activator instead of the magnesium salts, which are apparently too active. 8·7 gm. (100 m.moles) of lithium bromide in 35 ml. of tetrahydrofuran was added to 13·7 gm. (100 m.moles) of ethyl chloro-oxalate in 10 ml. of tetrahydrofuran at −30°. 7·1 gm. (50 m.moles) of dimethylcadmium in 20 ml. of tetrahydrofuran was added at − 65° in 1 hr., and stirred another hour at −65°. The tetrahydrofuran was distilled off *in vacuo* at 25°, the residue taken up in water, extracted with ether, the combined ether and tetrahydrofuran solutions freed of solvents, and the residue fractionated at a pressure of 18 mm. mercury. At 52–53°, 5·90 gm. (51 per cent theoretical yield) of ethyl pyruvate was obtained; phenylhydrazone (m.p. 114–115°, mixed melting point with authentic material 115–116°). Similarly, at −40°, substituting dibutylcadmium for the dimethylcadmium, ethyl α-ketohexanoate was obtained in 70 per cent yield. This is the first generally applicable organo-metallic synthesis of this type of compound; for Stacy and McCurdy[8], using an *in situ* organocadmium solution, obtained only traces of ethyl α-ketohexanoate from the reaction of dibutylcadmium with ethyl chloro-oxalate, although in special cases, with hindered arylcadmium reagents, yields were much better.

As the preparation of pure, distilled organocadmium compounds is somewhat cumbersome, the description of an experiment where this is avoided is given here. From 1·35 gm. of lithium metal and 11·6 gm. of butylbromide, an ethereal solution of butyllithium was prepared at − 30°. The 'double titration' method indicated that 68 m.moles of butyllithium was formed. This was transformed into a dibutylcadmium solution by admixing 9·3 gm. (34 m.moles) of cadmium bromide. After 30 min. stirring at 35°, the ether was distilled off *in vacuo* at room temperature, the residue dissolved in 45 ml. of tetrahydrofuran, and this solution, containing 34 m.moles of dibutylcadmium and 152 m.moles of lithium bromide, treated as above with ethyl chloro-oxalate. Ethyl α-ketohexanoate was obtained in a yield of 68 per cent of theoretical (7·44 gm.).

I have found that magnesium salts exert a similar 'salt effect' in the reaction of the organozinc compounds. Obviously, a potential activation of organometallic reactions could always be considered if salts are present in the systems employed. The Grignard compounds are of special interest: Raymond E. Dessy and co-workers[9] have demonstrated that ethereal solutions of ethylmagnesium bromide contain a complex with the formula $(C_2H_5)_2MgMgBr_2$ (and not the usually considered C_2H_5MgBr). Similarly, phenylmagnesium bromide solutions contain only the species $(C_6H_5)_2Mg.MgBr_2$. The usual higher reactivity of Grignard compounds as compared with the lower reactivity of the R_2Mg type compounds apparently represents another important case of activation of organometallic reactions by magnesium salts.

The mechanism of these reactions is being studied and experiments are being continued to apply the 'selective activation principle' to develop syntheses for other classes of compounds hitherto inaccessible by organometallic synthesis.

J. Kollonitsch

Merck, Sharp and Dohme Research Laboratories,
Division of Merck and Co., Inc.,
Rahway, New Jersey.

[1] Gilman, H., and Nelson, J. F., *Rec. Trav. Chim. Pays Bas*, **55**, 520 (1936).
[2] For reviews, see Cason, J., *Chem. Rev.*, **40**, 15 (1947). Shirley, D. A., "Organic Reactions", **8**, 28 (Wiley, New York, 1954).
[3] Krause, *Ber. deut. chem. Gesell.*, **50**, 1813 (1912).
[4] Cason, J., and Fessenden, R. J., *J. Org. Chem.*, **22**, 1326 (1957).
[5] *J. Amer. Chem. Soc.*, **81**, 968 (1959).
[6] Klemm, Mann and Lind, *J. Org. Chem.*, **23**, 349 (1958). Cason, J., and Smith, R. D., *ibid.*, **18**, 1201 (1953). Jones, Paul R., and Congdon, Stephen L., *ibid.*, **81**, 4291 (1959).
[7] Cason, J., and Reist, E. J., *J. Org. Chem.*, **23**, 1670 (1958).
[8] Stacy, G. W., and McCurdy, R., *J. Amer. Chem. Soc.*, **76**, 1914 (1954).
[9] Dessy, R. E., and Handler, G. S., *J. Amer. Chem. Soc.*, **80**, 5824 (1958) and earlier papers.

Detection of Iodine Compounds by Paper Chromatography

Kolthoff and Sandell[1] have found that minute amounts of iodine as iodide can be detected and determined by the ceric sulphate–arsenious acid reagent:

$$As^{3+} + 2Ce^{4+} \rightleftarrows As^{5+} + 2Ce^{3+}$$

They have pointed out that the effect of iodides on the reduction of the ceric ion by arsenite is catalytic.

Bowden, Maclagan and Wilkinson[2] have described methods for the detection of inorganic and organic iodine-containing compounds on paper chromatograms using the ceric–arsenious reaction. The positions of iodine-containing compounds were indicated by white spots on a yellow background. A difficulty encountered in this reaction is the fading of the chromatograms after some minutes due to the presence of small traces of atmospheric iodine.

We have overcome these disadvantages by exposing the chromatograms, immediately after development,

to vapours of a 50 per cent phenol solution and then drying in air; the white spots of iodine-containing compounds are fixed and a marked contrast against dark brown background is obtained. This seems to be due to the oxidation of phenol by the excess of ceric sulphate.

Under similar conditions α- and β-naphthols give white spots with a violet tinge, against a yellow background. Unfortunately these spots are not so easily obtained as those of phenol.

José M. Calvo
Luz Bascur

Instituto de Quimica Fisiologica,
Escuela de Medicina,
Universidad de Chile,
Santiago,
Chile.

[1] Kolthoff, I. M., and Sandell, E. B., *J. Amer. Chem. Soc.*, **56**, 1426 (1934).
[2] Bowden, C. H., Maclagan, W. F., and Wilkinson, J. H., *Biochem. J.*, **59**, 93 (1955).

Gas Chromatography of Unesterified Fatty Acids using Polyester Columns treated with Phosphoric Acid

The gas chromatography of unesterified fatty acids was first reported by James and Martin[1], who used a column liquid phase of silicone oil containing 10 per cent stearic acid. Beerthuis *et al.*[3] extended this work to higher fatty acids (C_{18} and higher) using silicone oil plus β-anthraquinone carboxylic acid and 'Apiezon *L*' grease as liquid phases. With these systems, considerable tailing of the peak occurs and extremely high column temperatures are required. The association phenomenon of the carboxyl group is responsible for the difficulty of the analysis.

More recently, several authors[3–5] have separated fatty acids of lower molecular weight using more polar liquid phases such as dioctyl sebacate plus sebacic acid[3] and polyesters of dibasic acids and glycols[4,5].

The extension of polyester phases to the analysis of higher fatty acids (C_{12}–C_{22}) would be advantageous because unsaturated could be separated from saturated acids at lower temperatures than with other phases. The disadvantages of polyesters are their poor thermal stability and high 'bleed' at temperatures higher than 220° C. Furthermore, the polyesters alone are not acidic enough to overcome completely the association phenomenon of the higher acids.

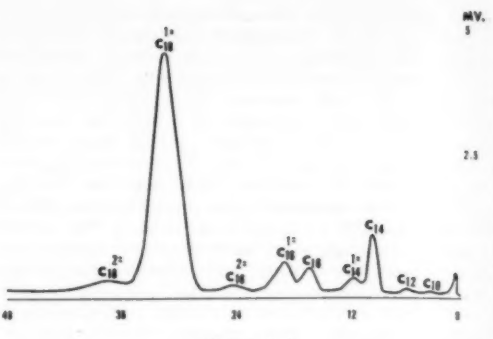


Fig. 2. Chromatographic analysis of a commercial oleic acid. Flash heater 270° C., column temperature 230° C., helium pressure 16 p.s.i., column size 100 cm. × 4 mm., hot-wire detector, sample size 3 μl.

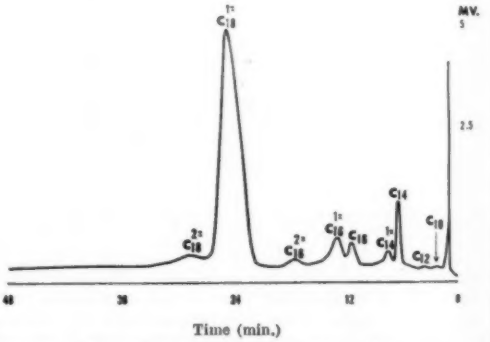


Fig. 3. Chromatographic analysis of the methyl esters of a commercial oleic acid. Flash heater 270° C., column temperature 180° C., helium pressure 16 p.s.i., column size 100 cm. × 4 mm., hot-wire detector, sample size 1 μl.

With a column having a polyester treated with phosphoric acid as the liquid phase, well-defined symmetrical peaks were obtained with C_4–C_{22} acids. Saturated and unsaturated acids were separated from each other. Separations were made at relatively low column temperatures of 220–235° C., and the columns appear to be extremely stable at these temperatures, being usable for several weeks with little loss in efficiency. At 180° C. methyl esters are also separable on the same columns with good peaks.

The column packing was 25 per cent (w/w) diethylene glycol adipate polyester[6] ('Lac-2-*R*-446', Cambridge Industries Co., Inc., 101 Potter Street, Cambridge 42, Mass.) and 2 per cent phosphoric acid (85 per cent H_3PO_4) on 60–80 mesh, acid-washed 'Celite 545'. The polyester was dissolved in chloroform and the 'Celite' added. Then the phosphoric acid was added to the slurry, the chloroform was removed by evaporation on a steam-bath with constant stirring, and the powder was placed in a vacuum oven at 60° C. for 24 hr. The coated

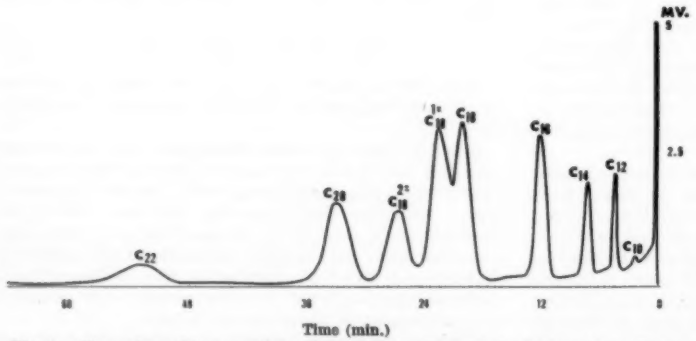


Fig. 1. Chromatographic separation of a mixture of long-chain fatty acids. Flash heater 270° C., column temperature 235° C., helium pressure 16 p.s.i. (45 ml./min.), column 100 cm. × 4 mm., hot-wire detector, sample size 3 μl.

'Celite' was finally vibration-packed in a copper U-tube (100 cm. × 4 mm.) and was conditioned for 16 hr. at 220° C. The gas chromatographic instrument was one of my own design utilizing Gow-Mac filaments for thermal conductivity detection.

The separation of a synthetic mixture of fatty acids from C_{12} to C_{22}, including some unsaturated acids, is shown in Fig. 1. The incomplete separation of the stearic and oleic acid peaks typical of this polyester could probably be improved by lengthening the column or by using another treated polyester. Fig. 2 shows the analysis of a commercial oleic acid at 230°, and Fig. 3 the analysis of the methyl esters of the same acid at 180° C. The fatty-acid sample was three times (3λ) as large as the methyl-ester sample (1λ) in order to achieve approximately the same thermal conductivity response.

Table 1. Comparative Gas Chromatographic Analysis of a Commercial Oleic Acid and its Methyl Ester

Acid	Free acid (per cent)	Methyl ester (per cent)
C_{10}	0·2	0·1
C_{12}	0·3	0·1
C_{14}	5·7	4·8
$C_{14}(^1=)$	2·7	2·1
C_{16}	4·2	3·9
$C_{16}(^1=)$	6·4	5·6
$C_{16}(^2=)$	1·2	1·4
$C_{18}(^1=)$	75·3	77·2
$C_{18}(^2=)$	4·2	4·8

Table 1 compares the analyses calculated from the areas under the peaks in Figs. 2 and 3. The differences in the analyses may be due to differences in thermal conductivity of esters and acids. Further work will be required to relate the peak areas of the free acids to true weight percentages of the various acids in the samples.

The polyester phase treated with phosphoric acid gives excellent separations and symmetrical peaks for the higher fatty acids. It should find many applications in biochemical and plant-control work. These liquid phases seem particularly stable to heat, possibly because of ester formation between phosphoric acid and the hydroxyl groups of the polyester.

This work will be described more fully elsewhere.

L. D. Metcalfe

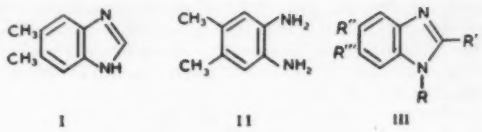
Armour Industrial Chemical Co.,
1425 West 42nd Street,
Chicago 9, Illinois.

[1] James, A. T., and Martin, A. J. P., *Biochem. J.*, **50**, 679 (1952).
[2] Beerthuis, R. K., Dijkstra, G., Keppler, J. G., and Recourt, J. H., *Ann. New York Acad. Sci.*, **72**, (13), 616 (1959).
[3] Raupp, G., *Angew. Chem.*, **71** 284 (1959).
[4] Böttcher, C. J. F., Clemens, G. F. G., and Van Gent, C. M., *J. Chromatog.*, **3**, 584 (1960).
[5] Hunter, I. R., Ortegren, V. H., and Pence, J. W., *Anal. Chem.*, **32**, 682 (1960).
[6] Lipsky, S. R., and Landowne, R. A., *Biochim. Biophys. Acta*, **27**, 666 (1958).

BIOCHEMISTRY

Effect of Some Benzimidazoles on a Vitamin B_{12}-requiring Alga

The identification of 5 : 6-dimethyl benzimidazole (I) as an acid degradation product of vitamin B_{12} was made in 1949 by Brink and Folkers[1] and independently by Holiday and Petrow[2]. The latter authors also speculated on the biogenesis of vitamin B_{12} and riboflavin, and suggested the possibility of their common derivation from 4 : 5-dimethyl-*o*-phenylenediamine (II)—a chemical precursor of (I). Furthermore, both these compounds were shown by Emerson *et al.*[3] to possess vitamin B_{12}-like activity in the rat. McNair Scott, Rogers and Rose[4] tested 49 substituted benzimidazoles on several bacterial systems—including the vitamin B_{12}-requiring *E. coli* 113-3. In particular, they found that —SH and —NO_2 substitution in the 4-position was associated with competitive vitamin B_{12} antagonism. More recently, Timmis and Epstein[5] demonstrated that 4,5,6-trichloro benzimidazole and its corresponding 1-β-D-ribofuranosyl were non-competitive and competitive antagonists respectively in the highly sensitive vitamin B_{12}-dependent flagellated green alga *Euglena gracilis* var. *z*.



I II III

A large series of benzimidazoles was synthesized in 1952 by Feitelson *et al.*[6], *inter alia* for the purpose of discovering vitamin B_{12} antimetabolites which might prove of value as chemotherapeutic agents in the treatment of cancer. The object of the present communication is to report the results of some growth-response tests with these compounds on the *E. gracilis* system.

Approximately 140 benzimidazoles were tested using techniques already described[5,7,8]. On preliminary examination, none was found to support algal growth in the absence of vitamin B_{12}, while 20 produced significant inhibition at low vitamin concentrations. The majority of the latter compounds were tested in subsequent assays to determine whether their inhibitory effects could be reversed or partially reversed by massive concentrations of vitamin B_{12}.

As can be seen (Table 1) no example of competitive or reversible antagonism was detected—a finding possibly related to the observation that (I) does not possess a vitamin B_{12}-like effect in *E. gracilis*.

Four benzimidazoles—Nos. 15, 16, 33 and 103—proved to be surprisingly toxic irreversible antagonists and at concentrations of less than 15 μgm./ml.

Table 1. Concentrations of Benzimidazoles producing 50 per cent Inhibition of Growth of *E. gracilis* var. *z*

Code No.	(III)				Concentration of drug (μgm./ml.) producing 50 per cent inhibition of growth. Vitamin B_{12} (μgm./ml.)		
	R	*R'*	*R''*	*R'''*	10	100	1,000
8	Me	H	NO_2	H	118	111	94
39*	H	$C_{12}H_{17}$	NH_2	H	317	221	219
40	H	CH_2Cl	H	H	63	75	72
41*	H	CH_2Cl	H	H	109	101	105
62*	CH_2Cl	H	H	H	170	180	171
68*	H	CH_2Cl	Me	H	463	405	408
76*	H	CH_2Cl	Me(C_4)	H	238	300	265
92	Et	H	Cl	Cl	90	63	56
101*	CH_2CH_2Cl	CH_2Cl	H	H	70	67	58
122	CH_2OH	H	H	H	74	74	72
127	Me	H	Me	H	440	427	377
128	H	Et	Cl	Cl	225	214	213
15	Me	CH_2Cl	H	Cl	2·5	3	2·5
16*	CH_2CH_2Cl	CH_2Cl	H	Cl	11	11	12
33*	CH_2CH_2Cl	CH_2Cl	Cl	H	9	14	13
103*	CH_2CH_2Cl	CH_2Cl	Cl	Cl	1·5	1·5	1·5

* Examined as hydrochloride.

produced 50 per cent inhibition of growth in the presence of up to 1,000 μgm./ml. of vitamin B_{12}. These compounds generally possess chloroalkyl groups in the 1- and/or 2-positions and chlorine substituents in the 5- and/or 6-positions. It is of interest to note that compound No. 101—designated by Feitelson *et al.*[6] in 1952 as "a novel type of nitrogen mustard"—was afterwards shown by Hirschberg, Gellhorn and Gump[9] to be highly toxic to both human and mouse brain tumour cells in tissue cultures. The enhancement of toxicity associated with progressive chlorine substitution on the benzene ring is strikingly exemplified by a comparison of the activities of compounds Nos. 101, 33 and 103 (Table 1). Since in all probability substitution of this type would lead to increased fat solubility, these differences in biological reactivity may well be associated with differences in the ratios of relative solubilities of these compounds in lipids and water. Such a mechanism has been suggested by Timmis and Hudson[10] in relation to the neutropenic effect of two homologous series of αΩ dimethanesulphonoxyalkanes.

I acknowledge the receipt of a British Empire Cancer Campaign grant. Dr. V. Petrow (B.D.H., Ltd., London) kindly supplied the compounds tested.

S. S. Epstein*

The Hospital for Sick Children,
Great Ormond Street,
London, W.C.1.

* Present address: Children's Cancer Research Foundation, Inc., Boston, Mass.

[1] Brink, N. G., and Folkers, K., *J. Amer. Chem. Soc.*, **71**, 2951 (1949).
[2] Holiday, E. R., and Petrow, V., *J. Pharm. Pharmacol.*, **1**, 734 (1949).
[3] Emerson, G., Brink, N. G., Holly, F. W., Koniuszy, F., Heyl, D., and Folkers, K., *J. Amer. Chem. Soc.*, **72**, 3084 (1950).
[4] McNair Scott, D. B., Rogers, M. L., and Rose, C., *J. Amer. Chem. Soc.*, **80**, 2165 (1958).
[5] Timmis, G., and Epstein, S. S., *Nature*, **184**, 1383 (1959).
[6] Feitelson, B. N., Mamalis, P., Moualim, R. J., Petrow, V., Stephenson, O., and Sturgeon, B., *J. Chem. Soc.*, 2389 (1952).
[7] Epstein, S. S., and Weiss, J. B., *Biochem. J.*, **75**, 247 (1960).
[8] Epstein, S. S., and Timmis, G. M., *Brit. J. Pharmacol. and Chem.* (in the press).
[9] Hirschberg, E., Gellhorn, A., and Gump, W. S., *Canc. Res.*, **17**, 904 (1957).
[10] Timmis, G. M., and Hudson, R. F., *Ann. N.Y. Acad. Sci.*, **68** (3), 727 (1958).

Enzymatic Transformation of Dehydroascorbic Acid to Diketogulonic Acid

The conversion of dehydroascorbic acid to diketogulonic acid has been studied in chemical systems[1]; but, as Harris[2] has pointed out, definite evidence is not available for any enzymatically catalysed transformation.

A search by us has shown that cauliflower (*Brassica oleracea botrytis*) and bitter gourd (*Momordica charantia*) possess an enzymatic mechanism for the conversion of dehydroascorbic acid to diketogulonic acid. The technique of investigation consisted in incubating homogenates with dehydroascorbic acid and following the course of reaction by estimating the amount of substrate disappearing and diketogulonic acid formed by the 2 : 4-dinitrophenylhydrazine method[3]. A system made up from heat-treated plant material was run simultaneously as control, and provided data for non-enzymic transformation. The homogenate was prepared by grinding the tissue with cold acetate buffer in a chilled Waring blendor, straining through muslin and making up to 20 per cent (w/v). In a typical assay 10 ml. of the enzyme, or the heat-treated, preparation was incubated with 3,000 μgm. of dehydroascorbic acid, the final volume being made to 30 ml. with buffer after adding any supplements. 5-ml. aliquots of the mixture were analysed at zero time and at the end of 60 min. of incubation at 37° C.

Table 1. Enzymatic Transformation of Dehydroascorbic Acid to Diketogulonic Acid in Cauliflower and Bitter Gourd

		Diketogulonic acid formed (per cent)	Dehydroascorbic acid disappearing (per cent)
	Cauliflower		
No. 1	Experimental	12·0	14·8
	Control	6·2	9·9
No. 2	Experimental, with added Mn^{++}, final concentration 0·001 M	12·4	13·0
	Control	5·7	5·7
	Bitter gourd		
No. 3	Experimental	8·9	10·1
	Control	2·9	2·9
No. 4	Experimental	17·9	17·9
	Control	9·5	8·3

Results recorded in Table 1 show that whereas spontaneous transformation of dehydroascorbic acid to diketogulonic acid occurred in all experiments, enzymic conversion also occurred, as evidenced by the fact that the transformation in the untreated homogenates was significantly higher than in the heat-treated controls.

We are grateful to the Council of Scientific and Industrial Research, New Delhi, for financial assistance.

C. P. Tewari
P. S. Krishnan

Biochemistry Division,
University of Lucknow.

[1] Penney, J. R., and Zilva, S. S., *Biochem. J.*, **37**, 403 (1943).
[2] Harris, R. S., in "The Vitamins", **1**, edit. by Sebrell, W. H., and Harris, R. S. (Academic Press, Inc., New York, 1954).
[3] Association of Vitamin Chemists, in "Methods of Vitamin Assay" (Interscience Publishers, New York, 1951).

Specific Protein of Legumes which reacts with Animal Proteins

Interactions of proteins among themselves, except immunological reactions, can be studied by various methods; but only in a few exceptional cases could they be demonstrated, as in the reactions of trypsin inhibitors and of agglutinins of legumes. Whether the *iso*hæmagglutinins in man are the result of immunization or are a direct product of the participation of blood-group genes has not yet been fully settled. But the proteins which are contained in some plants and agglutinate erythrocytes cannot be a result of immunization; they are, so to speak, natural antibodies. An antibody, however, is defined as a substance produced in response to an antigen. In this regard an antibody produced not in response to an antigen is self-contradictory. To avoid such confusion, Boyd[1] proposed the term 'lectin' for such substance as is produced not in response to an antigen but reacts more or less specifically with certain proteins or antigens.

It is already well established that agglutination and the precipitation can be caused by one and the

same antibody. Therefore the agglutinating 'lectin' can probably precipitate appropriate substances, and the distinction between agglutinating and precipitating 'lectin' may not be necessary. However, it is interesting that hitherto observations were made only on the agglutinating 'lectins' of plants. One of the reasons lies probably in the fact that the agglutination of erythrocytes is very sensitive. The second reason might be that such substances can be expected to be used as test substances for blood groups, while no direct application could be expected of a 'precipitating lectin'. On the other hand, observation of a precipitating 'lectin' is not always easy, because the formation of precipitate can also be caused by reactions other than a direct reaction of a protein with other proteins, for example, by the change of pH and/or salt concentration and so on.

In any event it was hoped that among the proteins of remote phylogenetic origin, there might be some which bind fairly firmly with each other, although specific reactions of proteins of animal origin among themselves occurred only exceptionally, apart from immunological ones. With the elaboration of 'crossing electrophoresis' developed in our laboratory[2], search was made for plant proteins specific for animal proteins in the extracts of some beans. In Fig. 1 is shown an example of 'crossing diagrams of human serum' against the extract of jack beans. From Fig. 1 it is clearly shown that the extract of jack beans contained a protein which reacted specifically with serum proteins. This specific protein, named provisionally protein *J*, migrated toward the cathode under the usual conditions of electrophoresis of serum at *p*H 8·6. It reacted with α_1-, α_2-, β-globulins and probably also with γ-globulin, but not with albumin.

That the peaks of the crossing diagram, especially those corresponding to α_1, α_2-, and β-globulins, consist of precipitate could be clearly shown by two-dimensional crossing electrophoresis in agar gel, as the thin film of gel was transparent. The precipitation could also be observed by Ouchterlony's method[3] as shown in Fig. 2.

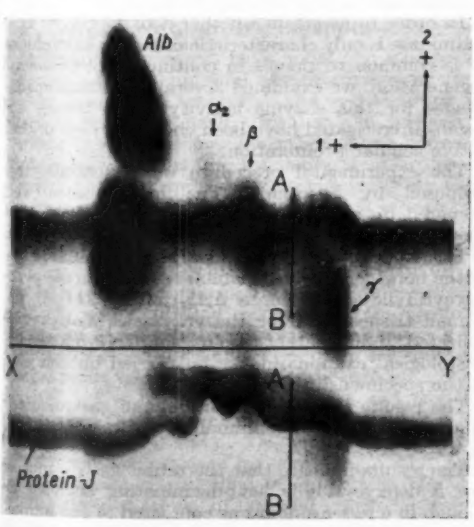


Fig. 1. Crossing diagram of human serum against protein *J* of jack bean. First electrophoresis: 0·003 ml./cm. of human serum was applied on lines *AB* and the first electrophoresis was carried out at 80 V. for 14 hr. Second electrophoresis: after the first one, 0·003 ml./cm. of water extract (5 : 1) of jack bean meal was applied on the line *XY* and the second electrophoresis was carried out at 120 V. for 8 hr. Barbiturate buffer, *p*H 8·6 and ionic strength, 0·05. Filter paper, Tōyō No. 52. Stained with amido-black 10 *B*

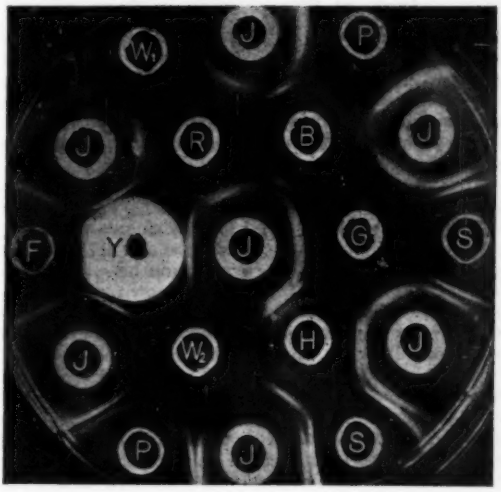


Fig. 2. Lines of precipitate appeared in the agar gel by the reaction of jack bean extract with animal proteins. *J*, Water extract of jack bean meal (5 : 1); *H*, human serum; *G*, guinea pig serum; *B*, bovine serum; *R*, rat serum; *S*, sheep serum; *P*, hog serum; *F*, fowl serum; W_1, egg white diluted with 4 vol. of physiological saline solution; W_2, egg white diluted eight times; *Y*, egg yolk diluted four times

As might be expected, the crossing diagrams of the sera of various animals showed species specificity, and human sera in some diseases showed distinct changes in pattern. Thus it is hoped to utilize the crossing diagrams of the sera against protein *J* for the diagnosis of certain diseases.

Further, protein *J* reacted with proteins of egg white as well as egg yolk. On the other hand, of the legumes hitherto tested, namely, kidney bean (uzura bean, *Phaseolus vulgaris* Linn.), 'torokusun' bean (a variety of the former), adzuki bean (*Adzukia angularis* Ohwi), cow-pea (sasage-bean, *Vigna sinensis* Savi), soy bean, and peanut, it was found that the kidney bean and 'torokusun' bean contained a similar protein, but their content was much smaller. From the crossing diagrams, it was found that they migrated toward the cathode with nearly the same mobility as protein *J* of jack bean and reacted chiefly with α_2-globulin of serum. It is suspected that they are of the same nature and that such proteins might be distributed fairly widely in legumes.

Detailed reports on the species specificity of the crossing diagrams of sera of various animals and the changes in diseases will be published elsewhere.

S. NAKAMURA
K. TANAKA
S. MURAKAWA

Institute for Medical Chemistry,
Yamaguchi Medical School,
Ube, Japan.

[1] Boyd, W. C., in "The Proteins", edit. by Neurath, H., and Bailey, K., **2**, 755 (Academic Press, Inc., New York, 1954).

[2] Nakamura, S., Hosoda, T., and Ueta, T., *Proc. Jap. Acad.*, **34**, 742 (1958). Nakamura, S., and Ueta, T., *Nature*, **182**, 875 (1958). Nakamura, S., Takeo, K., Katuno, A., and Tominaga, S., *Clin. Chim. Acta*, **4**, 892 (1959). Nakamura, S., Takeo, K., Tanaka, K., and Ueta, T., *Z. phys. Chem.*, **318**, 115 (1960).

[3] Ouchterlony, Ö., *Acta Path. Microbiol. Scand.*, **25**, 186 (1948).

Inositol Phosphatide in Peas

Some properties and analytical data concerning an inositol phosphatide of peas have been reported previously[1,2]. The availability of accurate methods for the determination of inositol in lipids, both by microbiological[3] and chemical means[4,5], has made it possible to conduct further experiments which are reported here.

The quantity of inositol phosphatide fraction obtained by Wagenknecht's modification of Carter's procedure[6] has been reported to increase during storage of raw peas (*Pisum sativum*) at −17·8° C. for periods of several days to several months[2]. Since this inositol phosphatide fraction is known to contain impurities it was thought desirable to determine whether the percentage of inositol in the fractions was constant with time over the entire period of frozen storage. Aliquots of the inositol phosphatide fractions obtained from peas of Pluperfect variety were subjected to hydrolysis with 4 *N* hydrochloric acid in sealed tubes at 120° C. for 16 hr. A modification of the periodate oxidation methods of Agranoff *et al.*[5] and Le Baron *et al.*[4] was used to determine inositol content of the hydrolysates. The results (Table 1) indicate that the percentage of inositol in these samples varies with time at −17·8° C., but the total weight of inositol in the fractions is relatively invariant over the period from two days to four months of storage.

Table 1. Inositol Content of Pea Inositol Phosphatide Fractions

Duration of frozen storage	Inositol* (per cent)	Inositol phosphatide (mgm.)	Inositol content (mgm.)
0 days	6·4	23	1·5
2 days	1·8	133	2·5
2 months	1·0	229	2·3
4 months	1·0	241	2·4
6 months	1·1	169	1·8

* Determined by modified periodate oxidation procedure (refs. 2, 4 and 5).

An enzymatic liberation of components of the inositol phosphatide fraction had previously been postulated, based on the observation that the inositol phosphatide content of raw (but not of heat-treated) peas increased with time[2]. On the basis of the results presented here it would appear that this increase is caused by the enzymatic liberation, during frozen storage, of inositol-free lipid materials the solubility properties of which are sufficiently similar to those of phosphatidyl inositol to allow them to be extracted with the inositol phosphatide fraction.

Although several components were known to be present in the inositol phosphatide fraction, as was shown by chromatographic methods[2], previous paper chromatographic results gave no evidence for the presence of free inositol. As a further check on the absence of free inositol a sample of the water-soluble intact potassium form, which had been prepared from the calcium–magnesium mixed salt as described in a previous publication[1], was analysed for inositol by the excellent microbiological assay of McKibbin[3], utilizing *Saccharomyces carlsbergensis* strain 4238. The purified potassium salt of the inositol phosphatide fraction was shown to contain less than 1 μgm. of free inositol per milligram.

Paper chromatographic evidence from another laboratory (Benson, A. A., personal communication) indicated that the calcium–magnesium mixed salts of pea inositol phosphatide contained, besides monophosphoinositide, components possessing the R_F values of glycerophosphorylglycerol, phosphatidyl ethanolamine, phosphatidic acid, and some free inositol. The results presented here confirm that the purified potassium salt of the inositol phosphatide fraction contains inositol only in the bound form.

L. M. Lewin*
A. C. Wagenknecht†
New York State Agricultural Experiment Station, Cornell University, Geneva, New York.

* Present address: Division of Biochemistry, Department of Biology, Massachusetts Institute of Technology.
† Present address: Fundamental Food Research Dept., General Mills, Inc., Minneapolis, Minn.

[1] Wagenknecht, A. C., Lewin, L. M., and Carter, H. E., *J. Biol. Chem.*, **234**, 2265 (1959).
[2] Lewin, L. M., and Wagenknecht, A. C., *Arch. Biochem. and Biophys.*, **87**, 239 (1960).
[3] McKibbin, J. M., in "Methods of Biochemical Analysis", 7, 111 (Interscience, New York, 1959).
[4] Le Baron, F. N., Folch, J., and Rothleder, E. E., *Fed. Proc.*, **16**, 209 (1957).
[5] Agranoff, B. W., Bradley, R. M., and Brady, R. O., *J. Biol. Chem.*, **233**, 1077 (1958).
[6] Wagenknecht, A. C., *J. Amer. Oil Chemists' Soc.*, **34**, 509 (1957).

5-Deoxycytidylic Acid-deaminating Activity in Human Gastric Mucosa and Other Adult Mammalian Tissues

The enzymatic deamination of deoxycytidylic acid to deoxyuridylic acid in sea urchin eggs and embryos has been demonstrated by Scarano[1] and Scarano and Maggio[2]. Moreover, later results obtained by Scarano and Tallarico[3] on the presence of deoxycytidylic acid-deaminase in livers of rat, chicken, rabbit in various stages of their embryonic development may indicate that this enzymatic activity, in developing or regenerating tissues, is proportional to their growth-rate. This latter view was confirmed in experiments by Maley and Maley[4] on the determination of this enzymatic activity in embryonic tissues, in some spontaneous and experimental tumours and in regenerating livers.

In order to ascertain whether deoxycytidylic acid-deaminase is only characteristic of tissues in evolution or is common to tissues in continuous physiological regeneration, we examined several adult mammalian tissues for this enzyme activity. The tissues and organs investigated have been chosen in view of their active cellular proliferation.

The experimental procedure was essentially that proposed by Scarano[1]. The homogenates were prepared by scrapping of the mucosa surface. The specific activity is referred to as μmoles of deoxycytidylic acid deaminated in 10 min. per 10 mgm. nitrogen of the homogenate (the deamination of 1 μmole of deoxycytidylic acid giving a ΔA_{280} of −0·344). The human tissues used for the enzymatic assays were collected immediately from surgical operations. Histological examinations were carried out on each of the specimens used.

The results obtained for the human gastro-enteric mucosa and for other mammalian tissues are reported in Table 1.

The results indicate that the rabbit gastric mucosa has a deoxycytidylic acid-deaminating activity although in a lesser amount as compared to the human. This enzymatic activity is not found in other segments of rabbit gastro-enteric mucosa and in testicle, being scarcely detectable in bone marrow. Cat and ox gastric mucosa have also been examined, and a very low deoxycytidylic acid-deaminating activity was found.

Table 1. 5-DEOXYCYTIDYLIC ACID-DEAMINATING ACTIVITY OF ADULT MAMMALIAN TISSUES

Human	stomach	11·05 ± 0·75 μmole/10 mgm. N per 10 min.
,,	ileum	6·66 ,, ,, ,,
,,	colon	10·67 ,, ,, ,,
,,	sigmoid colon	4·48 ,, ,, ,,
,,	rectum	4·39 ,, ,, ,,
Rabbit	stomach	1·57 ,, ,, ,,
,,	ileum	not detectable
,,	colon	not detectable
,,	testicle	not detectable
,,	bone marrow	scarcely detectable
Cat	stomach	scarcely detectable
,,	ileum	not detectable
,,	colon	not detectable
Ox	omasum	scarcely detectable

The failure to detect deoxycytidylic acid-deaminase in some tissues, as in the case of the bone marrow and testicle, does not mean that the enzyme is completely absent. The enzyme might either have been destroyed during the extraction, or be present in too small a concentration to be detected with our assays.

Chromatographic analysis of the deproteinized incubation mixtures confirmed the formation of deoxyuridylic acid in agreement with the spectrophotometric results.

Further investigations, now in progress, indicate the presence of deoxycytidylic acid-deaminase in human blood cells.

DINO GUERRITORE
VINCENZO ROCCHI
ANDREA SETZU

Scientific Department,
Istituto Regina Elena per lo studio e la cura dei tumori,
and
Institute of General Pathology,
University of Rome.

[1] Scarano, E., *Biochim. Biophys. Acta*, **29**, 459 (1958).
[2] Scarano, E., and Maggio, R., *Exp. Cell Res.*, **18**, 333 (1959).
[3] Scarano, E., and Tallarico, G., *Boll. Soc. Ital. Biol. Sper.*, **35**, 13 (1959).
[4] Maley, G. F., and Maley, F., *J. Biol. Chem.*, **234**, 11 (1959).

Serotonin in Pineapple

SEVERAL investigators have noted and studied the presence of serotonin and its precursors in fruit, mainly banana and tomato[1–4]. As well as aiding the study of serotonin itself, this has the purpose of warning against the possible misdiagnosis of malignant carcinoid tumours by analysis of urine for elevated 5-hydroxyindoleacetic acid-levels when these are spuriously high following a diet rich in serotonin or its precursors.

During work on urinary 5-hydroxyindoleacetic acid, I noted unusually high peaks of excretion following the ingestion of pineapple juice. A more systematic study was conducted to determine the serotonin content of canned and fresh pineapple juice. Three brands of canned pineapple juice were selected, and samples were taken directly from the cans after shaking well. The fresh fruit was peeled and the skin discarded. The rest was pulped in a vitamizer and stored at about − 7° C. The pulp was centrifuged and the supernatant used for analysis. Analysis was by the colorimetric method of Udenfriend *et al.*[5].

The three brands of canned juice contained 23 mgm. serotonin/l., 25 mgm. serotonin/l. and 25 mgm. serotonin/l. respectively and the fresh juice 12 mgm. serotonin/l. It is almost certain that serotonin exists in the free state in the fresh as well as in the canned juice. The smaller quantity in the fresh juice may be due both to the rather inefficient pulping method used compared with commercial juice extraction and to the possibility that canned juice is concentrated somewhat in the processing.

A study of the urinary excretion of 5-hydroxyindoleacetic acid following ingestion of pineapple juice was also carried out. Two adult male subjects each drank 500 ml. of commercial canned pineapple juice and gave urine samples over the following 6 hr. The samples were analysed for 5-hydroxyindoleacetic acid by the colorimetric method of Udenfriend *et al.*[6]. The method was slightly modified at the final stage, the ethyl acetate being saturated with water at room temperature immediately before use. This ensured that the final volume of aqueous phase was the same, regardless of the atmospheric temperature. Table 1 shows the pattern of excretion.

Table 1

Subject 1 Time	μgm./min. 5-hydroxyindoleacetic acid
7.15–10.30	1·8
	Pineapple ingested
10.30–11.45	22·1
11.45–12.50	31·2
12.50– 2.15	13·0
2.15– 3.15	7·7
3.15– 4.45	5·9
Subject 2	
7.45–10.30	3·0
	Pineapple ingested
10.30–11.20	8·6
11.20–12.25	30·5
12.25– 1.30	17·7
1.30– 3.00	9·8
3.00– 4.40	3·7

The rate of excretion per hour over this period has increased by approximately ten times.

It would seem, therefore, that pineapple can be added to the list of forbidden fruit in a diet where 5-hydroxyindoleacetic acid analyses are being conducted and may also open another avenue to the study of serotonin.

I wish to acknowledge the help of Mr. R. Horgan with the colorimetric procedures.

D. W. BRUCE

Department of Pharmacology,
University of Melbourne.

[1] Cartier, P., Moreau, J., and Geffroy, Y., *C.R. Soc. Biol.*, **152**, 902 (1958).
[2] Crout, J. R., and Sjoerdsma, A., *New Eng. J. Med.*, **261**, 23 (1959).
[3] Waalkes, T. P., Sjoerdsma, A., Creveling, C. R., Weissbach, H., and Udenfriend, S., *Science*, **127**, 684 (1958).
[4] West, G. B., *J. Pharm. Pharmacol.*, Supp. **11**, 275. T (1959).
[5] Udenfriend, S., Weissbach, H., and Clarke, C. T., *J. Biol. Chem.*, **215**, 337 (1955).
[6] Udenfriend, S., Titus, E., and Weissbach, H., *J. Biol. Chem.*, **217**, 499 (1955).

Nitrite Oxidation by *Nitrobacter* in the Presence of Certain Nitrophenols

IT was reported by Simpson[1] that 2,4-dinitrophenol, at a concentration of 1 m*M*, strongly inhibits nitrite oxidation by *Nitrobacter*, although compounds such as ethyl nitrite and nitromethane appeared to have no inhibitory action. Other workers[2] have, however, failed to obtain any inhibition with 2,4-dinitrophenol. We have therefore re-investigated the effect of this compound on nitrite oxidation.

The oxidation of nitrite, at an initial concentration of 10 m*M*, by washed suspensions of *Nitrobacter* was followed manometrically at 30° in the absence of 2,4-dinitrophenol and in the presence of varying concentrations of the compound. All experiments were performed in the presence of 0·05 *M* phosphate buffer *p*H 7·5 and the solution of 2,4-dinitrophenol

used was prepared in this buffer. It was found that the compound is a powerful inhibitor of nitrite oxidation and the inhibition produced by different concentrations is shown in Table 1.

Table 1. Inhibition of Nitrite Oxidation by 2,4-Dinitrophenol

Concentration of 2,4-dinitrophenol (m*M*)	Percentage inhibition of oxygen uptake
0·3	16
0·6	23
1·2	64
1·8	80
2·4	94

One possible explanation of the effect of 2,4-dinitrophenol is that, by virtue of its nitro groups, it can compete with nitrite for the nitrite-oxidizing enzyme. However, it was found that variation of the initial nitrite concentration between 6 and 44 m*M* had little effect on the degree of inhibition produced by a given concentration of 2,4-dinitrophenol. It therefore seems unlikely that such a competition between nitrite and 2,4-dinitrophenol occurs.

Another possibility is that 2,4-dinitrophenol inhibits because of its well-known ability to uncouple oxidative phosphorylation[3]. Although it has yet to be proved, it is almost certain that nitrite oxidation by *Nitrobacter* is linked to the production of high-energy phosphate bonds. If this phosphorylation is coupled in an obligatory way, then any uncoupling agent should inhibit nitrite oxidation. The effect on nitrite oxidation of two dyes, janus green and brilliant cresyl blue, both of which have been shown to uncouple oxidative phosphorylation in mammalian systems[4], was therefore tested, but neither had any effect at concentrations up to 10 m*M*. It is possible, however, that neither dye could penetrate to the site of nitrite oxidation within the cell.

The effect on nitrite oxidation of a few compounds related to 2,4-dinitrophenol was also tested, and the results are given in Table 2. All conditions were the same as in the experiments with 2,4-dinitrophenol; each compound was used at a concentration of 1 m*M*.

Table 2. Effect on Nitrite Oxidation of Some Compounds Related to 2,4-Dinitrophenol

Compound tested	Percentage inhibition of oxygen uptake
2,5-Dinitrophenol	61
m-Nitrophenol	77
p-Nitrophenol	100
p-Nitroaniline	25
Phenol	7

It is of interest that the nitrophenols produced the greatest inhibition, and it appears that both the phenolic hydroxyl and nitro groups are necessary to give the maximum effect. As in the case of 2,4-dinitrophenol, inhibition may be due to a direct action on the nitrite oxidizing enzyme, or to an uncoupling of oxidative phosphorylation.

W. D. Butt*
H. Lees†

Department of Biological Chemistry,
University of Aberdeen.

* Present address: The Molteno Institute, Downing Street, Cambridge.

† Present address: Chemistry Department, Ontario Agricultural College, Guelph, Ontario.

[1] Simpson, J. R., in "Studies on the Biochemistry of the Nitrifying Bacteria", 61, Ph.D. thesis (Aberdeen, 1955).

[2] Engel, H., Krech, E., and Friederichsen, I., *Arch. Mikrobiol.*, **21**, 96 (1954).

[3] Loomis, W. F., and Lipmann, F., *J. Biol. Chem.*, **179**, 503 (1949).

[4] Judah, J. D., and Williams-Ashman, H. G., *Biochem. J.*, **48**, 33 (1951).

PHYSIOLOGY

Inhibition of Appetite in Dairy Cattle by Certain Intermediate Metabolites

Manning *et al.*[1] have discussed the applicability of the glucostatic theory of Mayer *et al.*[2] to the regulation of food intake in sheep. Glucose in ruminant animals plays a relatively minor part in energy metabolism, since a major portion of ingested carbohydrates are degraded to volatile fatty acids which are absorbed into the blood stream via the rumen wall[3]. Consequently, a chemoreceptor mechanism of regulation of intake in ruminants may depend on any of several metabolites. The objective of this experiment was to examine several major intermediate metabolites for their effect on appetite.

Sodium acetate (adjusted with acetic acid to *p*H 7), glucose, acetic, propionic, valeric, hexanoic and lactic acids were administered intravenously by constant drip over the same 8-hr. period during each of three consecutive days. In each trial, identical twin cows of the Guernsey, Holstein-Friesian or Jersey breed were injected. One twin received the metabolite in three litres of physiological saline and the other received an equal amount of physiological saline. The injections were made into the jugular vein through a small polyethylene catheter inserted previously that remained in place throughout each trial. The catheter was firmly attached to the shoulder of the animal, thus allowing all manipulations to be made at that position. This technique permitted the elimination of any restraining apparatus other than a halter, to which the animals were already accustomed. The injection procedure and experimental manipulation apparently did not affect intake, since the control twins consumed the same amount of feed during the three-day injection period as they did during the three days prior to injection. The effect on appetite was determined by comparing the voluntary hay intake of chopped alfalfa of the control twin (saline injected) with that of the treatment twin (metabolite injected). The relative amounts of each metabolite administered are shown in Table 1. These amounts are expressed as a percentage of body maintenance requirement[4]. So far as possible, the higher levels of organic acids used were those corresponding to what would seem to be equal to, or in excess of, the actual amounts absorbed from the gastro-intestinal tract during an 8-hr. period.

Administration of glucose did not elicit a reduction in daily intake. This is in agreement with the observation of Vallance and McClymont[5] during injection of 4 kgm. of glucose over a 48-hr. period, and that of Manning *et al.*[1] following intravenous administration of 50 per cent glucose to sheep. In the case of the higher (25 per cent) level, concentrations of blood glucose were raised from approximately 40 mgm. per 100 ml. to approximately 100 mgm. per 100 ml., or about 2½ times normal. From these results, it is clear that raised levels of blood glucose have little or no effect on the appetite of dairy cattle.

The administration of the higher level of acetic acid and sodium acetate resulted in a highly significant reduction in feed intake during the 8-hr. injection period; with both metabolites consumption was negligible. Consumption during the other 16 hr. of the three injection days approached normal. However, the 24-hr. feed-intake values during the three days were significantly lower for the treatment

Table 1. Effect of Intravenously Administered Metabolites on Consumption of Feed by Identical Twin Cows

Metabolite	Level*	No. of trials	Average intake during 8-hr. injection period, 3 days. Treated twin (lb.)	Control twin (lb.)	Average 24-hr. intake including 8-hr. injection period, 3 days. Treated twin (lb.)	Control twin (lb.)
Glucose	4·0	2	8·2	9·2	19·5	18·8
Glucose	25·0	2	5·8	6·4	16·4	15·8
Sodium acetate	12·5	2	0·5§	8·4	14·0†	20·2
Acetic acid	12·5	1	0·8§	6·3	3·1‡	17·9
Acetic acid	4·0	1	14·8	14·1	27·1	28·6
Acetic acid	3·5	1	6·8	9·3	18·1	16·6
Propionic acid	12·5	2	2·1§	10·0	15·1‡	23·6
Butyric acid	6·25	2	14·7	14·7	27·6	28·0
Valeric acid	6·25	2	15·4	18·8	30·4	32·8
Hexanoic acid	6·25	2	12·0	12·6	28·8	29·6
Lactic acid	6·25	2	19·8	20·4	32·2	34·6

*Percentage of body digestible energy maintenance requirement. †Significant ($P < 0.05$). ‡Significant ($P < 0.01$). §Significant ($P < 0.005$).

twins than for the control twins. Administration of propionic acid resulted in significant reductions in intake during the 8-hr. and 24-hr. periods. There was very little carry-over effect from acetate, acetic or propionic acid injections, since eating began very soon after cessation of each 8-hr. injection period.

None of the other metabolites mentioned above caused a significant reduction in feed intake. Valeric acid and lactic acid injection resulted in a small mean reduction in intake, but the results were variable and exhibited no definite trend.

The results of this series of trials strongly suggest the existence of a chemoreceptor response to changes in blood constituents. Apparently, one of the possible mechanisms of regulation of intake involves the absorption of acetic acid and propionic acid or, as indicated by the experiment using sodium acetate, the acetate and propionate ions, into the blood stream which, at threshold levels, would elicit a chemoreceptor response inhibiting intake. Acetic and propionic acid inhibition of feed intake may account for the observation that dairy cattle consume less forage in the form of silage than in the form of hay, since silage contains significant amounts of these acids.

The level of feed consumption (highly variable in ruminants) is of the utmost importance, since gross efficiency of milk production is limited by voluntary intake of nutrients. From the results of this experiment, it is postulated that rations tending to promote the production of metabolites serving as energy sources that do not inhibit nutrient consumption could greatly enhance the gross efficiency of animal production by promoting an increase in voluntary intake of nutrients.

Donald R. Dowden
Don R. Jacobson

Department of Dairy Science,
University of Kentucky,
Lexington, Kentucky.

[1] Manning, R., Alexander, G. I., Krueger, H. M., and Bogart, R., *Amer. J. Vet. Res.*, **20**, 242 (1959).
[2] Mayer, J., and Bates, M. W., *Amer. J. Physiol.*, **168**, 812 (1952).
[3] Barcroft, J., McAnally, R. A., and Phillipson, A. T., *J. Exp. Biol.*, **20**, 120 (1944).
[4] National Research Council Publication 464 (1956) gives daily maintenance requirement of a 1,000-lb. cow as 14·1 therms of digestible energy; adjustments for variation in body-weight were proportional to 0·75 log body-weight.
[5] Vallance, W. S., and McClymont, G. L., *Nature*, **183**, 446 (1959).

Electrical Inexcitability of the Synaptic Membrane in the Frog Skeletal Muscle Fibre

Various types of evidence indicate that the endplate potential of frog twitch muscle fibres is an electrically inexcitable synaptic activity[1,2]. Electrical inexcitability of the synaptic membrane has been demonstrated most clearly in cells in which electrically excitable activity is lacking, for example, the electroplaques of marine electric fishes[3] and slow muscle fibres of frog[4]. Electrical inexcitability of synaptic membranes in other cells has also been demonstrated[1,2]. Hitherto, however, it has not been shown that the chemically excitable[5] synaptic membrane of twitch muscle fibres is also unresponsive to electrical stimuli. The junctional region is small, and there is intermingling of membrane of greater and lesser chemical sensitivity[5].

Experiments described here demonstrate that sites of the junctional membrane do not develop an inward current when a directly evoked spike is propagated through the endplate region. These are also the sites with the largest and most rapidly rising externally recorded spontaneous miniature endplate potentials.

Most of the work was done on whole sartorius muscles of frog (*Rana pipiens*). A few experiments were performed on isolated single nerve–muscle fibre preparations from the semitendinosus muscle, the results being identical in both series. The preparations were bathed in hypertonic saline, made by doubling the sodium chloride of a standard frog Ringer's solution. Hypertonicity served two functions: decreasing the contraction of the muscle[6] and increasing the frequency of spontaneous miniature endplate potentials[7]. The latter effect aided location of synaptic sites, which appear to be distributed as small patches in the junctional region[5].

Superficial nerve endings to a neuromuscular junction were visualized, and a recording microelectrode was inserted into this region of the muscle fibre. Spikes were elicited by depolarizing pulses which were applied through another intracellular electrode in the same muscle fibre at some distance away from the junction. An external recording micro-electrode was used to explore the endplate region for discrete areas of spontaneous sharply rising external negativities. The potentials were recorded with direct coupled amplifiers.

When the external micro-electrode was localized at a site which yielded rapidly rising outside-negative miniature endplate potentials, the potential recorded during the spike was purely positive (Fig. 1*A*). On moving the micro-electrode in the long axis of the fibre less than 5μ from this site a brief dip developed in the positivity (Fig. 1*B*). The dip became larger when the electrode was moved slightly farther away (Fig. 1*C*). Negativity developed on moving the electrode another 30μ (Fig. 1*D*). Further displacement of the electrode by about 100μ resulted in a potential with a very large negativity (Fig. 1*E*). This last was the potential usually recorded outside the muscle fibre at non-synaptic regions.

Invasion of the junctional region by the directly evoked spike was confirmed by the records obtained with the intracellular micro-electrode (Fig. 1*F*). The externally probed site which gave the purely positive potential of Fig. 1*A* was shown to give rise to spontaneous negativities both before and after the spikes

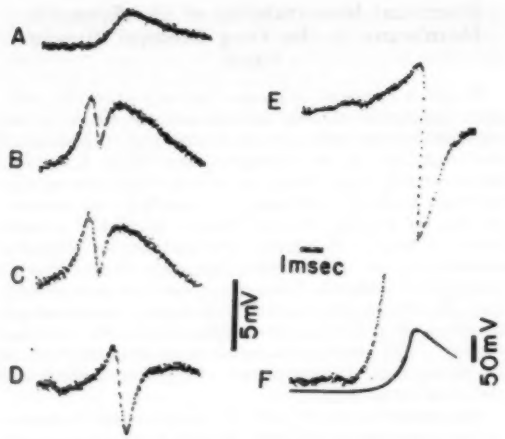


Fig. 1. Potentials at different sites outside endplate of single semitendinosus muscle fibre (*R. pipiens*) during passage of directly evoked spike. Latter is shown (*F*) as recorded intracellularly at endplate region with low amplification and simultaneously at gain used for extracellular recordings (*A–E*). The spikes were elicited by long, weak intracellular depolarization, to minimize stimulus artefact. Accordingly, latency varied in different records. *A*, positivity recorded at endplate site which also yielded maximal, steeply rising, externally negative miniature endplate potentials *B–E*, changes produced on moving external microelectrode away from this site, as described in text. Amplitudes in different records cannot be compared, since they depend on closeness of micro-electrode to surface of membrane. Records retouched

were elicited, thus demonstrating the undamaged state of the recording site. Large negativities associated with spikes were never recorded from sites producing rapidly rising miniature end-plate potentials. At non-junctional regions external positivities were seen only in grossly damaged fibres.

The potential recorded by a closely placed external electrode is proportional to the membrane current[6], a negative potential indicating inward current and activity of the region probed by an external microelectrode. Thus, the purely positive potentials recorded at restricted sites of the synaptic region indicate that these sites remained inactive during passage of the impulse while sites less than 100μ away were excited by the initial outward depolarizing local circuit current and gave rise to large external negativity. The brief dips in the positivity recorded at intermediate sites reflect the distribution of current flows in regions near both active and inactive membranes.

The same regions that are inactive during passage of a spike are capable, however, of becoming active, passing an inward current and generating the externally negative miniature end-plate potentials. The regions in which the external miniature end-plate potentials are largest and steeply rising are also the sites which are most sensitive to ionophoretic applications of acetylcholine[5]. It may be reasonably concluded, therefore, that the sites of the junctional membrane which generate miniature end-plate potentials and which respond by depolarization to chemical excitants are also the neurally excitable synaptic sites of the neuromuscular junction. They are electrically inexcitable, at least by stimuli representing a change in membrane potential of more than 120 mV., the spike amplitude of the muscle fibre.

This work was supported in part by funds from Muscular Dystrophy Association of America, Inc., National Institute of Neurological Diseases and Blindness, National Science Foundation and United Cerebral Palsy Research Association, in grants to Dr. H. Grundfest.

Robert Werman*

Department of Neurology,
College of Physicians and Surgeons,
Columbia University, New York.

* Special Traineeship (*B*-374) of National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

[1] Grundfest, H., *Physiol. Rev.*, **37**, 337 (1957).
[2] Grundfest, H., "Handbook of Physiology-Neurophysiology", 1, Chap. 5 (Amer. Physiol. Soc., Washington, D.C., 1959).
[3] Bennett, M. V. L., Wurzel, M., Amatniek, E., and Grundfest, H., *Biol. Bull.*, **115**, 331 (1958).
[4] Burke, W., and Ginsborg, G. L., *J. Physiol.*, **132**, 586 (1956).
[5] del Castillo, J., and Katz, B., *J. Physiol.*, **132**, 630 (1956).
[6] Howarth, J. V., *J. Physiol.*, **144**, 167 (1958).
[7] Fatt, P., and Katz, B., *J. Physiol.*, **117**, 109 (1952).
[8] Lorente de Nó, R., "Studies from the Rockefeller Institute for Medical Research", Chap. 16, 132 (1947).

Absorption and Excretion of Copper in Mice

The marked elevation of tissue copper that occurs in Wilson's disease is generally thought to be due to an increased absorption of copper from the gastrointestinal tract[1,2]. In the work reported here, this concept was re-examined.

Swiss albino mice, 5–7 weeks of age, were kept on a diet providing 45–75 μgm. copper a day per mouse. Various amounts of copper, to which copper-64 was added, were then given orally or intravenously. Intravenous injections were given in a 3–5 sec. period; in oral administration, 0·2 ml. of the copper solution was passed into the stomach through a polyethylene catheter. Three mice from each group given a specific copper dose were bled at intervals for organ and serum radiocopper assays and at least 5 mice were used for collection of urine and fæces.

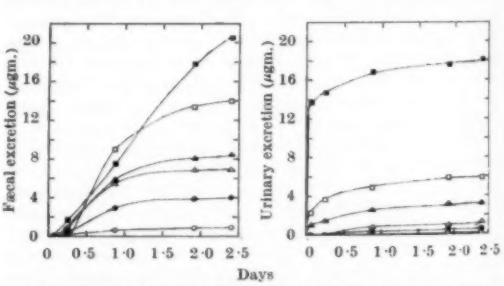


Fig. 1. Cumulative fæcal and urinary excretion of a copper dose after intravenous injection. ○, 1·7 μgm.; ●, 6·3 μgm.; △, 11 μgm.; ▲, 15·5 μgm.; □, 25 μgm.; ■, 48 μgm.

The fæcal excretion of a copper dose after intravenous injection of amounts from 1·7 μgm. to 48 μgm. is shown in Fig. 1. The larger the dose of copper given, the greater was the amount of copper excreted; 96 μgm. injected under these conditions was lethal to half the mice within 1 hr. Since, after intravenous administration, copper appears in fæces principally through biliary excretion[3], it would seem that the amount of copper excreted in bile by the normal animal increases with increasing copper loads. In accord with this, following the injection of 0·15, 1·1, 3·2, 11 and 48 μgm. copper, at least 0·05, 0·63, 1·7, 6·7 and 15 μgm. respectively were found in the liver 10 min.–7 hr. after administration; hepatic

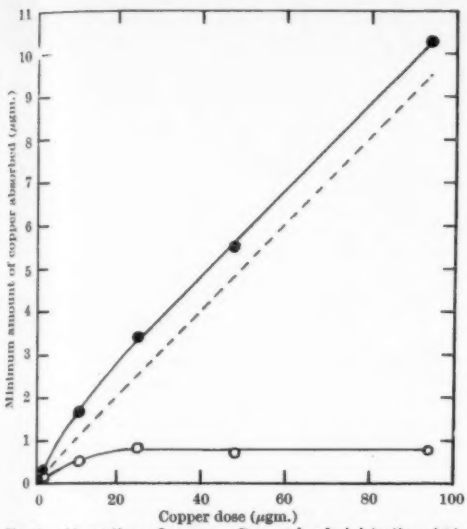


Fig. 2. Absorption of copper after oral administration (●). Dashed line passing through origin and parallel to absorption curve at doses of 25 μgm. or more represents hypothetical first-order process; ○, total absorption curve less the first-order absorption process

radiocopper then decreased and was afterwards found in the fæces. The concentration of copper in several bile samples obtained from animals killed 21 hr. after injection was found to increase with the size of the dose. In contrast, the concentration of copper in bile in Wilson's disease is in the normal range despite the presence of a markedly increased hepatic copper pool[2,3].

When mice were given 46 μgm. copper intravenously once a day for 6 days, the fæcal excretion of the last dose was similar to that of the first dose. Since only part of each dose was excreted before injection of the next, all preceding doses added to the total copper excretion. Thus, even with continued copper administration, the larger the copper load, the greater was the fæcal copper excretion.

With intravenous doses of copper of 0·15–11 μgm., only a small fraction of the dose appeared in the urine (Fig. 1). With 48 μgm., almost 30 per cent of the dose was excreted within 90 min.

The maximum amount of copper present in the body at one time represented the minimum amount of copper absorbed, and was estimated by subtracting the radiocopper present in the gastrointestinal contents from that in the total body. The results are shown in Fig. 2. It can be seen that the larger the dose the greater was the amount of copper absorbed. There appeared to be at least two processes involved in absorption: one appeared to be first-order and the other suggested an enzymatic mechanism.

When mice were injected with 46 μgm. stable copper intravenously or 92 μgm. stable copper subcutaneously once a day for 6 days prior to the oral administration of 1·7 μgm. labelled copper, the absorption of labelled copper was 75 and 58 per cent of normal, respectively. This finding is the converse of that found in Wilson's disease and is in accord with a dilution of the oral copper in the copper excreted into the intestinal tract from the injected load.

The results presented in this communication suggest that the elevation of tissue copper in Wilson's disease is probably due to a defect in biliary copper excretion rather than an increase in copper absorption.

David Gitlin*
Walter L. Hughes
Charles A. Janeway
Department of Pediatrics, Harvard Medical School, Boston, Mass.
Brookhaven National Laboratory, Medical Division, Upton, New York.

* Established Investigator, American Heart Association.

[1] Bearn, A. G., and Kunkel, H. G., *J. Lab. and Clin. Med.*, **45**, 623 (1955).
[2] Bush, J. A., Mahoney, J. P., Markowitz, H., Gubler, C. J., Cartwright, G. E., and Wintrobe, M. M., *J. Clin. Invest.*, **34**, 1766 (1955).
[3] Denny-Brown, D., and Porter, H., *New England J. Med.*, **245**, 917 (1951).

Growth of Mouse Femurs during Continual Centrifugation

The size and shape of various parts of an organism are believed to be influenced by gravity[1]. One would expect the relative size and cross-section of supporting structures to increase with either an individual's height or the intensity of the environmental gravity.

Gray and Edwards first experimentally demonstrated such a gravitational influence on the cross-section shape of a growing structure by continual centrifugation of wheat coleoptiles[2]. Smith and his co-workers found that this would increase the size of chicken legs[3]. This report deals with the greater size and altered shape of mouse femurs.

This is one aspect of a long-range programme designed to study the influence of gravity on development. In this particular work, the *NLW* strain of five-week-old white mice were exposed to continual centrifugation at four times the Earth's gravity (4*g*). Duration of exposure was for periods of 1–8 weeks. The diet consisted of 'Purina' laboratory chow for mice and uncooked potatoes. These potatoes served as the only source of water. The centrifuge is described elsewhere[4]. A number of anatomical and physiological measurements were performed at the termination of exposure. The details of these determinations will be described later. The effect on the femurs of female mice was more striking than many other effects.

As can be seen from Fig. 1, experimental animals first lost mass and then continued to grow. At the end of one week they had returned to approximately initial body mass. The femurs, on the other hand, continued to grow just as fast, if not faster, than the controls. At later developmental stages, this rapid growth of experimental bones is not as pronounced. The femurs also assumed a more circular cross-section. Other factors being equal, such a change would give a supporting structure more strength with which to support gravity.

There are at least two possible explanations for the faster bone growth as compared to total experimental growth: mechanical stress and moderate starvation. Wolff's law proposes that mechanical force will evoke growth of the stressed portion of the bone[1]. The artificial increase in the force of weight during centrifugation could certainly cause such stresses. The initial decrease in body mass can be largely attributed to a lowered food consumption during the first week of centrifugation. In cases of moderate starvation, bone developmental responses demonstrate a lag, being in most cases among the last organs to show growth retardation[5]. Further work

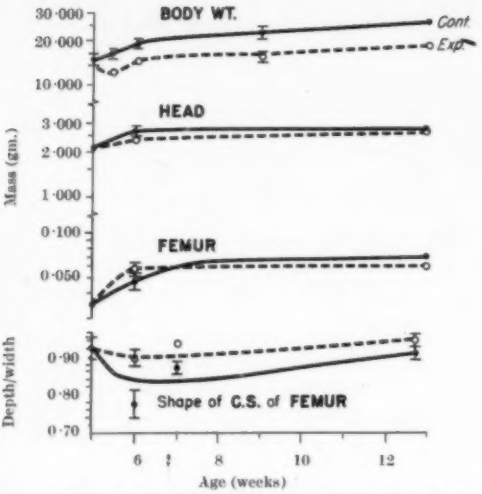


Fig. 1. Growth of various structures of the female white mouse during centrifugation at 4*g*. The experimental points at one week and eight weeks of exposure represent determinations with nine and seven animals respectively. These animals were killed at the appropriate time. Body masses at zero time are based on the averages for these 16 animals. Other values from zero time were for five mice which were killed at five weeks of age. Control values are from individual litter mates of the experimental animals. These animals grew in cages identical to those placed in the centrifuge. The index for shape of the femur cross-section is calculated by dividing the shorter thickness (depth) by the greater thickness (width). Solid lines are for control curves and broken lines for experimental curves. Standard errors are indicated by the extent of the vertical lines above or below the experimental points. When these errors are not shown for the animals at two and four weeks it is because results are based on less than three measurements. In other cases the extent of the error is less than the extent of the points

is necessary to demonstrate the actual cause or causes for the relative increase in size of femur. Starvation alone does not seem a very plausible explanation for change in cross-section. The shorter axis of the bone shaft, being mechanically weaker, should be the most susceptible to a growth-enhancing stress, thus producing greater roundness.

This investigation was supported by a grant from the U.S. Public Health Service.

Charles C. Wunder
Stanley R. Briney
Melvin Kral
Charles Skaugstad

Department of Physiology,
State University of Iowa,
Iowa City, Iowa.

[1] Thompson, D'A. W., "On Growth and Form", second ed., 22, 194, 958 (Cambridge University Press, 1942).
[2] Gray, S. W., and Edwards, B. F., *J. Cell. and Comp. Physiol.*, **46**, 97 (1955).
[3] Kelly, G. F., Smith, A. H., and Winget, W. M., Ann. Prog. Rep., ONR, Project *NR*, 102 (1957).
[4] Walters, G. R., Wunder, C. C., and Smith, L., *J. App. Physiol.* (in the press).
[5] Jeans, P. C., and Stearns, G., *J. Pediatrics*, **13**, 730 (1938).

Evidence of a Specific Action on the Central Nervous System by the Esters of Some Plant Growth Regulator Acids

The pharmacology of plant-growth regulator acids has been little studied; nevertheless, these substances which react in minute traces in green plants possess intense biological activity. We have prepared various esters of these acids with the intention of studying their action on the central nervous system. Dimethylaminoethanol was chosen as the agent of esterification because Pfeiffer *et al.*[1] had demonstrated that this amino-alcohol has stimulating effects. We have synthesized the dimethylaminoethylic esters of the following acids: phenoxyacetic acid and some of its derivatives substituted on the aromatic nucleus (4-chloro-, 4-fluoro-, 2,4-dichloro-, 2-methyl-4-chloro-compounds), naphthalenic acid, α- and β-naphthoxy-acetic acid, 3-indolylacetic acid, phenylpropionic acid.

The method of preparation and the physical constants of these products have already been described[2].

Pharmacological study of these different substances has shown that they possessed a specific action on the central nervous system, principally at the level of the hypothalamus[3]; this property is not due exclusively to dimethylaminoethanol since it can be substituted by other amino-alcohols; but on the other hand the acidic group seems to be the important part of the molecule. Among the compounds studied, the dimethylaminoethylic ester of *para*-chlorophen-oxyacetic acid (which we term 235 *ANP*) was particularly active.

The oral *L.D.*50 of 235 *ANP* is 1,750 mgm./kgm. Rats treated chronically at 400 mgm./kgm. a day during three months and longer tolerate this dose without any blood, hepatic or renal troubles.

(*a*) The specific action on the central nervous system was shown in the following experiments:

Fish (*Cyprinus vulgaris*, *Phoxinus phoxinus* Linné) immersed in a 0·5/1,000 solution of the 235 *ANP* in water exhibit convulsive seizures and dilation of chromatophores. The Siamese fighting fish, even in the absence of a male congener, develops its fins, expands its chromatophores, and attains a fighting temperament.

In mice, autographic records showed that after administering 150 mgm./kgm. subcutaneously of 235 *ANP* for ten days a significant increase in spontaneous activity could be observed.

In the rabbit, 100 mgm./kgm. of 235 *ANP* injected intravenously significantly lowered the threshold for seizures from intravenously infused metrazol.

(*b*) The specific effect of 235 *ANP* on the hypothalamus was demonstrated with the help of B. Minz's method[4].

It is known that the application of a piece of filter paper of 5 mm.², steeped in adrenaline solution (5/100), on the fronto-parietal cortex of a female rabbit causes arterial hypertension and uterine contractions, due to the secretion of hypertensive and oxytocic substances by the hypothalamus[5].

The same reactions occur in a hypophysectomized animal; but they are suppressed if the hypothalamus is destroyed[6].

We have confirmed the correctness of this method, which permits us to study the effect of psychotropic drugs on the hypothalamus[7].

We have observed that the 235 *ANP* provokes a considerable stimulation of the hypothalamic area (Fig. 1).

The other compounds, derived from plant-growth regulator acids which were prepared, are still being studied; so far we have already examined the effect of the substances on the chromatophores of fish, on glycæmic regulation and their relationship with catecholamines and serotonin.

Already the results achieved suggest research on the manner in which the esters of plant-growth

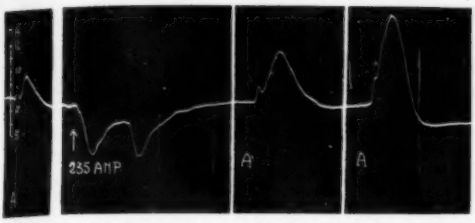


Fig. 1. Blood pressure record. *A*, Application of adrenaline on the fronto-parietal cortex of a rabbit. After intravenous injection of 235 *ANP* (50 mgm./kgm.) one can observe a considerable increase of the hypertensive reaction

regulator acids exert their stimulation. So far three possibilities have been examined :

(*a*) The potentialization of the central action of adrenaline by a stimulation of the cerebral cortex induced by the drug. (*b*) Direct action on the hypothalamus and hypophysis or on the level of catecholamines and serotonin, which are found in great quantities in this region. (*c*) Regularization by 235 *ANP* of the metabolic activity of the hypothalamic region could explain some of the powerful actions of the drug.

Pharmacological and biochemical studies are now being carried out with the view of explaining the mechanism of action of 235 *ANP* and other esters of plant-growth regulator acids, which seem to act as metabolic regulators at the level of the hypophyseal–hypothalamic region.

J. Thuillier
Clinique des Maladies Mentales,
Institut National d'Hygiène,
Hôpital Ste Anne, Paris.

Germaine Thuillier
P. Rumpf
Centre d'Etude et de Recherche de Chimie
Organique Appliquée,
C.N.R.S. Bellevue (Seine et Oise).

[1] Pfeiffer, C. C., Jenney, E. H., Gallagher, W., Smith, R. P., Bevan, jun., W., Killam, K. F., Killam, E. K., and Blackmore, W., *Science*, **126**, 610 (1957).
[2] Thuillier, G., Rumpf, P., and Thuillier, J., *C.R. Acad. Sci., Paris*, **249**, 2081 (1959).
[3] Thuillier, J., Rumpf, P., and Thuillier, G., *C.R. Soc. Biol.*, **153**, 1914 (1959).
[4] Minz, B., Buser, B., and Albe-Fessard, D., *C.R. Soc. Biol., Paris*, **147**, 1154 (1953).
[5] Chamorro, A., and Minz, B., *C.R. Soc. Biol., Paris*, **151**, 272, 496 (1957).
[6] Chamorro, A., and Minz, B., *C.R. Soc. Biol., Paris*, **151**, 214 (1957).
[7] Minz, B., Thuillier, J., and Nakajima, H., *C.R. Soc. Biol., Paris*, **153**, 744 (1959).

HÆMATOLOGY

Glutathione Stability Test in Hæmoglobin *E* – Thalassæmia Disease

Hæmoglobin *E* – thalassæmia disease represents a double heterozygous state with reference to genes for hæmoglobin *E* and thalassæmia. Studies on glutathione stability which have recently provided valuable information regarding the cause of hæmolysis as it occurs in drug-induced hæmolytic anæmia and in hereditary non-spherocytic hæmolytic anæmia have not so far been done in hæmoglobin *E* – thalassæmia disease. In the present communication, 20 cases of hæmoglobin *E* – thalassæmia disease were investigated with reference to the behaviour of their erythrocytically reduced glutathione-level when incubated *in vitro* with acetylphenylhydrazine. The relevant features of these 20 cases are given in Table 1.

Table 1. Relevant Features of Twenty Cases of Hæmoglobin *E* – Thalassæmia Disease

	Mean	Range
Age (yr.)	5·8	1–28
Hæmoglobin (gm. per cent)	6·44	3·4– 9·28
Hæmoglobin *F* (per cent)	23·8	13·0–50·0
Reticulocytes (per cent)	8·1	2·1–17·0

The method employed was essentially the same as originally evolved by Beutler[1]. In order to increase the sensitivity of the test, 4 mgm. of glucose was added to 1 ml. of blood as suggested by Szeinberg *et al.*[2] and later adopted by Beutler[3]. With this method, the range of reduced glutathione destruction in the normal Bengalee population varied from 1 to 10 mgm. per 100 ml. of erythrocytes. Two apparently normal persons, however, showed unstable glutathione-level, indicating that a certain proportion of Indians has such glutathione instability similar to the state of instability reported first in people of negroid origin[5,6] and later in those of Syrian, Iranian and Jewish[2] extraction. In contrast to the normal findings, the pattern in hæmoglobin *E* – thalassæmia disease was different (Table 2). In 12 out of 20 cases, the glutathione destruction exceeded 30 mgm. per 100 ml. of erythrocytes and in 9 the post-incubation level was lower than 30 mgm. In all the patients, both sensitive and non-sensitive, glucose-6-phosphate dehydrogenase activity of red cells was, however, found to be high.

Table 2. Results of Glutathione Stability Test in Normals and in Hæmoglobin *E* – Thalassæmia Disease

	No. of subjects	Reduced glutathione-level in mgm. per 100 ml. of erythrocytes			
		Range		Mean	*S.E.*
Non-sensitive normals	20	Before	47–95	65·05	2·1483
		After	40–89	61·60	2·6173
Non-sensitive hæmoglobin *E* – thalassæmia	8	Before	19·6–92	54·48	8·0291
		After	17·6–92	51·70	7·4065
Sensitive hæmoglobin *E* – thalassæmia	12	Before	41·5–82	63·275	1·3039
		After	0–50	27·5	5·2448

Sushiela Swarup
S. K. Ghosh
J. B. Chatterjea

Hæmatological Unit,
Indian Council of Medical Research,
and
Department of Hæmatology,
School of Tropical Medicine,
Calcutta.

[1] Beutler, E., *J. Lab. Clin. Med.*, **49**, 84 (1957).
[2] Szeinberg, A., Sheba, Ch., and Adam, A., *Blood*, **13**, 1043 (1958).
[3] Beutler, E., *Blood*, **14**, 103 (1959).
[4] Kimbro, E. L., *Bull. Johns Hopkins Hosp.*, **101**, 118 (1957).
[5] Zinkham, W. H., and Childs, B., *J. Clin. Invest.*, **36**, 938 (1957).
[6] Walker, D. G., and Brown, J. E., *Nature*, **184**, 1325 (1959).

Blood Groups of Selected Aboriginal and Indigenous Populations

The Laboratory of Physical Anthropology at Yale is investigating the distribution of the following genetic traits in various populations of Primates, including man : the blood groups, the serum transferrins (β-globulins), haptoglobins, and hæmoglobin

variants. This is a report of the bood types in three of the human populations investigated.

(*A*) *Kapauku Papuans.* Seventy samples of venous blood were obtained from the inhabitants of the West Central Highlands of New Guinea. These people occupy an area between 135° 25′ and 137° longitude and 3° 25′ and 4° 10′ south latitude. They are referred to as *Kapauku* by coastal inhabitants of Netherlands New Guinea and call themselves *Me*. The frequencies are reported in Table 1. The discovery of two Diego-positive individuals is not wholly unexpected for this area. It has not, however, been reported before. The frequencies of the ABO(H) blood types are different from those published for other Papuan groups by Sanger *et al.*[1] and Bijlmer[2–4]. No attempt was made to select a random sample, since our research is aimed at relating the social structure of aboriginal human groups to gene frequencies. Therefore, blood samples are taken, when possible, from individuals that are related to one another by some network of social relations. Thus, the fact that the ABO(H) frequencies differ radically from others reported from Papua, particularly in the unusually low frequency of type A, may be due to our deliberate attempt to select related individuals. However, the Kapauku are an isolated people, a factor which must be considered.

Table 1. Kapauku Papuans

A_1	7	K+k+	1
O	52	K−k+	69
B	11	Di^a+	2
M	1	CCDee	50
N	52	CcDEe	13
MN	17	CcDee	4
Fy^a+	70	ccDEe	1
U+	70	ccDee	1
P+	25	C^wcDEe	1
Kp^b+	70		

Nijenhuis[5] reports the presence of the Henshaw (He) antigen among Papuans. Fifty-one of our samples were tested with an He reagent. All were Henshaw-negative.

(*B*) *Indigenes of Providencia Isla, Colombia.* Providencia is an island off the coast of Colombia. Forty-two samples of venous blood were drawn and typed. The results are reported in Table 2. The population is a mixture of Indian, Negro and White. All C-positive bloods were C^w negative. Published frequencies of blood types from Colombia report only Indian populations, thus comparisons are not possible at present.

Table 2. Indigenes of Providencia

A_1	3	K+k+	1
A_2	2	K−k+	41
O	23	Kp^b+	42
B	14	ccDee	20
M	12	CcDee	13
N	9	ccDEe	4
MN	21	ccddee	2
Mg−	42	CCDee	1
P+	39	CcDEe	1
Fy^a−	42	$ccD^{u}ee$	1
Di^a−	42		

(*C*) *East Africans.* One hundred and eighty-nine bloods from several Kenya tribes were tested. Table 3 reports the frequencies found in the entire group, which consisted of Masai, Wakamba, Luo, Kikuyu, Giriama and Pokomo tribesmen. The Masai samples were drawn at Kajiado Hospital, which serves the Masai tribe. The Wakamba samples were drawn at the village of Mulutui, near Kibwezi railroad station. The rest were drawn from patients at the George VI hospital in Nairobi and the Coast Province Hospital in Mombasa.

Table 3. East Africans

Blood types	Wakamba	Masai	Coast tribes Pokomo, Giriama	Upland tribes Luo, Kikuyu
A_1	7	17	7	2
A_2	5	3	1	0
O	21	38	21	8
B	16	24	11	1
A_1B	0	0	1	0
A_2B	1	4	1	0
ccDee	37	62	27	8
CcDee	7	10	4	2
ccDEe	5	9	7	0
$ccD^{u}ee$	1	0	0	0
Ccddee	0	1	0	0
CcDEe	0	1	2	1
ccDee	0	2	0	0
CCDee	0	1	0	0
ccddee	0	0	2	0
M	14	37	11	3
N	8	10	9	4
MN	28	39	22	4
K−k+	50	86	40	11
K+k+	0	0	2	0
P+	48	84	40	9
P−	2	2	2	2
Fy^a+	0	2	4	0
Fy^a−	50	84	38	11
U+	50	86	42	11
Di^a−	50	86	42	11

The frequencies are generally similar to those reported by Foy *et al.*[6] and Allison *et al.*[7]. The number of A_2B samples seems unusually high and cannot be explained by our non-random method of sampling. Each A_2B individual is clearly unrelated to the others. All C-positive bloods were tested and found to be C^w negative.

The co-operation of colleagues at the Nairobi Medical Research Laboratories, Dr. L. M. J. Couvee of Bialk, New Guinea, and Dr. Alvarao Garcia N. of San Andres, Colombia, is gratefully acknowledged. Dr. Fred Allen, Boston Blood Grouping Laboratory, provided the anti-Mg sera, and Dr. M. Layrisse of Caracas, Venezuela, provided the anti-Di^a sera. This research is supported by *RG* 6053 of the United States Public Health Service, and was aided by the Wenner-Gren Foundation and United States Atomic Energy Commission Grant *AT*-(11-1)-405 to the University of Michigan.

John Buettner-Janusch

Department of Anthropology,
Yale University.

Henry Gershowitz

Department of Human Genetics,
University of Michigan,
Ann Arbor, Michigan.

Leopold J. Pospisil
Peter Wilson

Department of Anthropology,
Yale University.

[1] Sanger, R., Walsh, R. J., and Kay, M. P., *Amer. J. Phys. Anthrop.*, N.S., **9**, 71 (1951).
[2] Bijlmer, H. J. T., *J. Roy. Anthrop. Inst.*, **65**, 123 (1935).
[3] Bijlmer, H. J. T., *Genetica*, **23**, 257 (1942–43).
[4] Bijlmer, H. J. T., *Geneesk. Tijdschr. Ned. Ind.*, **75**, 2186 (1935).
[5] Nijenhuis, L. E., *Vox Sanguinis*, **3**, 112 (1953).
[6] Foy, H., Kondi, A., Timms, G. E., Brass, W., and Bushra, F., *Brit. Med. J.*, **i**, 294 (1954).
[7] Allison, A. C., Broman, B., Mourant, A. E., and Ryttinger, L., *J. Roy. Anthrop. Inst.*, **86**, i, 87 (1956).

Interrelations of Serum Protein Fractions in Normal Humans

RECENT advances in the study of protein–protein interactions[1], including the haptoglobin–hæmoglobin[2] and protamine–fibrinogen[3] complexes, have stimulated interest in serum protein abnormalities such as macroglobulin aggregation[4]. Although the serum proteins frequently undergo significant alterations with the onset of disease and yield characteristic patterns on electrophoretic separation, little is known about their interdependence in the healthy state. The present report describes an electrophoretic examination of interrelations between protein fractions in the course of variations within the normal human range.

Blood was obtained from 100 healthy persons between the ages of sixteen and seventy-two. There were equal numbers of males and females. Serum proteins were separated by cellulose acetate electrophoresis and stained with lissamine green. The dyed fractions were eluted, and the concentrations of albumin and α_1-, α_2-, β-, and γ-globulins then calculated by comparing the quantity of eluted dye with the known dye uptakes of standard preparations. Since for each sex the means between the corresponding fractions were not significantly different, the two groups were combined. Table 1 summarizes the results.

Table 1. MEANS AND STANDARD DEVIATIONS OF SERUM PROTEIN FRACTIONS OF 100 NORMAL PERSONS

	Albumin	Globulins α_1	α_2	β	γ
Mean (gm./100 ml.)	4·07	0·30	0·78	0·92	1·29
± Standard deviation	0·37	0·04	0·11	0·12	0·23

The five fractions were approximately normally distributed and, using standard statistical procedures, the partial correlation coefficients of the ten possible pairs were determined. Table 2 indicates that the most significant values were obtained for the pairs derived from the α_1-, α_2-, and β-globulins. It is noteworthy that the least significant values are those of pairs involving γ-globulin of reticulo-endothelial origin with the other proteins of hepatic origin.

Table 2. PARTIAL CORRELATION COEFFICIENTS OF NORMAL SERUM PROTEIN FRACTIONS

	Globulins α_1	α_2	β	γ
Albumin	−0·183	−0·145	0·210	0·031
α_1-Globulin		0·987	0·317	0·067
α_2-Globulin			0·247	−0·046
β-Globulin				0·029

The virtually perfect correlation between α_1- and α_2-globulins is explicable in terms of similarity of constitution. Both fractions comprise glycoproteins and lipoproteins, and have sedimentation rates close to 3 Svedberg units[5]. Similarly, the α_1-globulin–β-globulin correlation can be considered to result from the lipid moiety common to each; both sediment at 5 S[5]. The lower correlation between α_2- and β-globulins may be attributable to the glycoproteins and lipoproteins contained in each. Both sediment in the ultracentrifuge at 7 and 12 S[6].

The most significant negative correlation was found for albumin–α_1-globulin. In this connexion Schultze[7] has noted that some α_1-globulin is carried by albumin under paper electrophoretic conditions, while Tata[8] has demonstrated the existence of a prealbumin–α_2-globulin complex. Of interest is the present finding that the albumin–γ-globulin relation is not inverse as it frequently is in disease. It is certain that the behaviour of some protein fractions as dependent variables is, like their distribution[9], governed by experimental conditions.

C. J. BRACKENRIDGE

Biochemistry Department,
Royal Perth Hospital,
Perth,
Western Australia.

1 Waugh, D. F., *Adv. Protein Chem.*, **9**, 325 (1954).
2 Jayle, M. F., *Bull. Soc. Chim. Biol.* (Paris), **21**, 14 (1939).
3 Mylon, E., Winternitz, M. C., and Sütö-Nagy, G. J., *J. Biol. Chem.*, **143**, 21 (1942).
4 Deutsch, H. F., and Morton, J. I., *Science*, **125**, 600 (1957).
5 Brattsten, I., *Ark. Kemi*, **8**, 347 (1956).
6 Wallenius, G., Trautman, R., Kunkel, H. G., and Franklin, E. C., *J. Biol. Chem.*, **225**, 253 (1957).
7 Schultze, H. E., *Clin. Chim. Acta*, **3**, 24 (1958).
8 Tata, J. R., *Nature*, **183**, 877 (1959).
9 Armstrong, S. H., Budka, M. J. E., and Morrison, K. C., *J. Amer. Chem. Soc.*, **69**, 416 (1947).

PATHOLOGY

A New Factor in the Use of Antibiotics

NEW clinical problems have arisen from the intensive use of antibiotics during the past twenty years. During this time, several aspects of those problems have been studied in an attempt to elucidate the various mechanisms related to the sensibility, resistance and dependence of micro-organisms as well to the mode of action of antibiotics.

When observations are made, not *in vitro*, but in host organisms, the interpretation of the phenomenon becomes more confused due to the many variables taking part in the problem and to the effect of antimicrobial activity added to humoral defensive responses of the host against the pathogenic agent. In these responses, both the drug effect breaking down the equilibrium of normal phagocytic activity and the formation of antimicrobial antibodies are often found.

Irregularities in the activity of antibiotic suspensions have been observed by us between serum of patients having different levels of antibiotic and their specific antimicrobial activity, as well as when looking at the behaviour of bacteria against the antibiotics or their associations. Certain irregularities were found in associations of antibiotics of known *in vitro* bactericidal activity when this activity was greatly reduced *in vivo*, during treatment of the parasitized organism. In spite of adequate dosing, sera of various patients with analogous symptoms and under the same treatment showed differences in their antimicrobial activity, which could not be explained satisfactorily.

These abnormalities could not be easily explained either by differences of antibiotic absorption or by different physiological responses of the human body, either by sex or by age, constitution, etc. It becomes necessary to consider a very representative factor common to the characteristics of previous treatments.

These observations lead us to think of the existence of antagonistic substances, not natural, but of a circumstantial origin in the host organism and capable of being formed as a response to an external stimulus promoted by the drug.

According to this hypothesis, experiments were carried out with various antibiotics, 'Kanamycin' being the first studied. This substance was injected into rabbits through peritoneal and endovenous routes at regular intervals for one month. Doses were steadily increased from 10 to 200 mgm. At the end of each treatment, a total amount of 450 mgm./kgm. had been injected into each rabbit, 12 animals having been used in each lot. The doses of 'Kanamycin' used were not toxic to the rabbits.

Checks of anti-'Kanamycin' activity of normal fresh serum were provided, using samples of blood extracted by heart-puncture from the test animals in advance of their treatment.

The technique used for studying the anti-'Kanamycin' activity of sera was as follows : 0·2 ml. of rabbit serum was placed in small test-tubes of about 1·2 ml. capacity and another 0·2 ml. into 400 ml. solution of 'Kanamycin' was added. A series of two-fold dilutions followed until a 0·097 concentration of 'Kanamycin'/ml. was obtained. Therefore, concentrations of the antibiotic in the assay ranged from 200 to 0·097γ. For each series a 'time of contact' was established (Fig. 1). Parallel tests using sera from untreated rabbits were performed for every series as control of normal sera activity. The series were finally completed—at the end of every conventional 'time of contact'—with 0·2 ml. of a bacterial suspension of *Staphylococcus aureus* Heatley (Oxford 657). The bacterial suspension, a 10^{-5} dilution from an 18-hr. culture in nutrient broth at 37° C., was prepared according to techniques already described (Portolés, 1960). Experiments were repeated three times and the results are recorded in Fig. 1.

As seen in Fig. 1, the results have been expressed as the minimum inhibitory concentration of 'Kanamycin' per ml. required to avoid the development of *S. aureus*. From these results it is concluded :

(*a*) That growth of *S. aureus* was inhibited by 0·28γ ml. of 'Kanamycin' using nutrient as substrate. 0·28γ ml. was taken as the standard value of 'Kanamycin' activity ; (*b*) that normal rabbit sera had a bacteriostatic activity which was equivalent after proper calculations to 0·19γ ml. of 'Kanamycin' ; (*c*) that the series of dilutions of 'Kanamycin' in normal rabbit sera gave an inhibition of *S. aureus* at concentrations ranging from 0·097γ to 0·12γ ml. ; (*d*) that the series of dilutions of 'Kanamycin' in immuno-sera obtained from rabbits previously treated with the antibiotic decreased the inhibitory effect of *S. aureus* development. The experiments showed that in this case greater amounts of 'Kanamycin' were required to obtain an effect similar to that of 0·28γ ml. in nutrient broth. The values increased with the 'time of contact' from 6·35γ ml. after 4 hr. to 24·63γ ml. after 24 hr.

Intradermic tests were also made in the treated animals, using 0·15 ml. standard solutions of the antibiotic at 40·0, 20·0, 10·0, 5·0, 1·25, 0·62 and 0·31γ ml. in distilled water, pyrogen-free, as well as 0·15 ml. of saline solution. All tests were negative.

From these results it seems conclusive that in the sera of rabbits previously treated with 'Kanamycin' there exists a substance which specifically inactivates the antibiotic. The substance apparently acts proportionally to the 'time of contact', for the antibiotic activity of 'Kanamycin' on *S. aureus* is remarkably reduced. The nature of the agent responsible for this blocking action against the antibiotic is not understood. Experiments made up to the present have demonstrated, however, that it cannot be included in the group of precipitins, but more precise results have been obtained by deviation complement tests. The latter results have shown the presence of certain specific anti-'Kanamycin' antibodies at 1/5 sera dilutions against concentrations of 10 mgm. 'Kanamycin' per ml.

The presence of this new factor in the sera of animals treated with an antibiotic suggests the importance of considering in the therapeutics of antibiotics the close interrelationship between the antibiotic and host-organisms as well as the possible influence of the latter relationship in the so-called 'resistance' to antibiotics.

Genoveva Tejerina
Antonio Portolés

Instituto "Jaime Ferran" de Microbiologia,
Consejo Superior de Investigaciones Cientificas,
Velazquez, 138,
Madrid, 6.

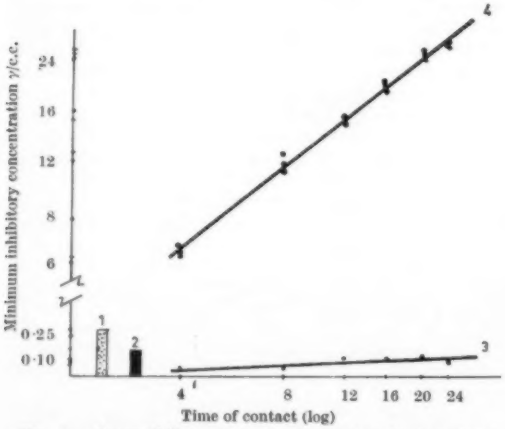


Fig. 1. Susceptibility of *S. aureus* Heatley (Oxford 657) : (1) to 'Kanamycin' in nutrient broth ; (2) to normal rabbit serum ; (3) to 'Kanamycin' diluted at various concentrations in untreated rabbit serum ; (4) to 'Kanamycin' diluted at various concentrations in rabbits' sera obtained from animals previously injected with 450 mgm./kgm. of 'Kanamycin' at regular intervals during one month

A Rapid Method of preparing Pure Serum Gamma-Globulin

In the course of investigating various methods of isolating skin-sensitizing antibodies from human allergic serum, a procedure has been devised which could be applied to the rapid preparation of other 7*S*-type gamma-globulins in a high degree of purity. The technique employs diethyl amino ethyl cellulose anion exchanger, prepared according to the method used by Peterson and Sober[1], to adsorb out of the serum all proteins other than 7*S*-type gamma-globulins. For this purpose, a batch process has proved superior to the more widely used column chromatography, because of its greater speed and ease of manipulation.

A small portion (2·5 ml.) of human serum, previously dialysed for 16 hr. at 4° C. against 1 litre of sodium phosphate buffer (*p*H 7·5, 0·01 *M*) containing 0·015 *M* sodium chloride, is added dropwise with continuous stirring to moist diethyl amino ethyl cellulose (17 gm. wet weight) which has been equilibrated and mixed with 2·5 ml. of similar buffer

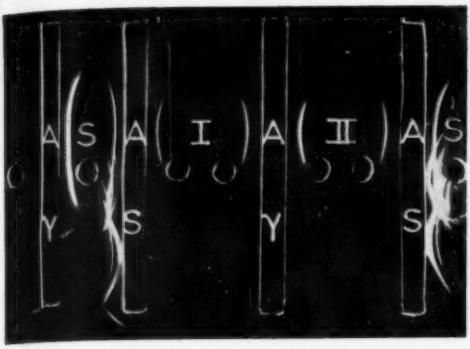


Fig. 1. Immunoelectrophoretic patterns of human serum (*S*) and purified gamma-globulin fractions (I and II) after testing with rabbit anti-human serum (*A/S*) and anti-human gamma-globulin (*A/γ*)

pre-cooled to 4° C. After the mixture has stood at 4° C. for 5 hr., a further 5 ml. of buffer is added with stirring and the resultant slurry is centrifuged in a cooled tube at 3,000 r.p.m. for 15 min. The supernatant (fraction I) contains highly pure gamma-globulin in a concentration of the order of 100–200 mgm./100 ml. (comprising a yield of approximately 50 per cent). A slightly less pure preparation (fraction II) is obtained by a repeat rinse of the exchanger with a further 5 ml. of phosphate buffer (0·01 *M*), still at *p*H 7·5.

The immunoelectrophoretic patterns shown in Fig. 1, obtained by testing with rabbit anti-human serum and anti-human gamma-globulin, reveal fractions I and II to be composed entirely of gamma-globulin. Small amounts (1–3 per cent) of a beta-globulin contaminant—probably siderophilin—can be detected, however, by testing with a more potent specific antiserum against alpha- and beta-globulins.

Quantitative gel-diffusion precipitin analyses with specific rabbit-antisera against alpha$_2$-glycoprotein and 19*S*-type gamma-globulin (kindly carried out by Dr. J. F. Soothill) demonstrated that the gamma-globulin fractions I and II were completely free from these high-molecular weight proteins. This finding was substantiated by *iso*-agglutinin titrations, employing type A and type B cells, which failed to detect any activity in either fraction although the initial serum possessed a 1/32 titre against type *A* cells and a 1/16 titre against type *B* cells.

As seen in Fig. 2, analytical ultracentrifugation in a Spinco model *E* machine also failed to reveal any 19*S*-type component (in fraction I and II solutions containing approximately 300 mgm. protein/100 ml.).

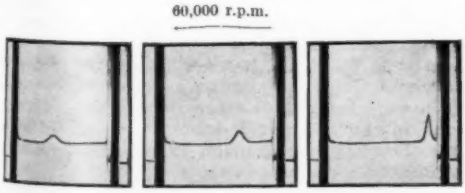


Fig. 2. Ultracentrifugal patterns of gamma-globulin fraction I concentrated two-fold by ultrafiltration. Protein concentration, approximately 300 mgm./100 ml.; solvent, sodium phosphate buffer (*p*H 6·9, 0·06 *M*) containing 0·15 *M* sodium chloride; speed, 60,000 rev./min.; temperature, 20° C.; $S_{20,w}$ = 6·9*S*

It is also interesting to note the absence of 10*S*-type component, which often appears in gamma-globulin preparations obtained by low-temperature procedures with ethanol and ether; nor could any 4·5*S* component be detected.

The batch process outlined above can be speeded up by omitting the initial overnight equilibration of serum with buffer, although this results in the sacrifice of a slight degree of purity of the gamma-globulin obtained. This modification offers an additional advantage, however, in that the whole procedure can then be more readily carried out under aseptic conditions. Such an adaptation has proved most useful in the preparation of skin-sensitizing antibody fractions (unpublished work), which have to be assayed by passive transfer into human recipients.

Summarizing briefly, the method described provides a convenient way of obtaining small quantities of purified gamma-globulin quickly and with minimum manipulation by a relatively mild treatment. It seems probable that it could be extended to preparations on a considerably larger scale.

I acknowledge the interest Prof. J. R. Squire has taken in this work. Ultracentrifugal analyses were carried out by Miss P. Ratcliff on a machine generously provided by the Rockefeller Foundation, New York.

D. R. Stanworth
Department of Experimental Pathology,
The Medical School,
Birmingham, 15.

[1] Peterson, E. A., and Sober, H. A., *J. Amer. Chem. Soc.*, **28**, 751 (1956).

Inhibition of Ehrlich Ascites Tumour Growth by Surface-active Agents

A recent communication by Townsend, Morgan and Hazlett[1] suggests that admixture of 10-hydroxy-Δ^2-decenoic acid with tumour cells will prevent growth of the cells on inoculation into mice. Similar results have been obtained by this group with other dicarboxylic acids[2]. In the course of work on the action of surface-active agents on tumour cell membranes[3], we have noted similar inhibition of growth of Ehrlich ascites tumour cells.

Ehrlich ascites tumour was grown in Swiss mice and removed after seven days. The cells were washed in sterile 0·15 *M* saline and resuspended in the same solution. Surfactant was added to the desired concentration, an aliquot removed for counting[4], and portions of the remainder used to inoculate mice. The final concentrations of surfactants were those known to foster 100, 99, 90 or 50 per cent staining by nigrosin. Groups of five mice were used for each concentration. The survivals of mice injected with our strain of Ehrlich ascites, untreated, are shown in Table 1.

Table 1. Survival of Mice Inoculated with Graded Numbers of Untreated Ehrlich Ascites Cells

Log No. cells	No. of mice (tumours/inoculated)	Days to death from tumour*
1	0/7	†
2	0/10	†
3	0/10	†
4	3/5	23–80 (42)
5	5/5	15–21 (18)
6	5/5	15–21 (19)

* Figures in parentheses are averages.
† Survivors killed at 85 days and no tumour found.

Table 2. Survival of Mice Inoculated with Graded Numbers Surfactant-treated Ehrlich Ascites Cells

Surfactant	Log No. unstained cells*	% Staining	No. of mice (tumours/ inoculated)	pH	Days to death from tumour‡
None	6	0	8/8	6·6	13–30 (20)
Sodium lauryl sulphate	–	100	0/5	6·5	†
	4	99	0/5	6·4	†
	5	90	0/5	6·5	†
	5·7	50	3/5	6·4	25–46 (35)
'*DM*-710'	–	100	0/5	6·2	†
	4	99	0/5	6·2	†
	5	90	0/5	6·1	†
	5·7	50	0/5	6·2	†
Lauryl pyridinium chloride	–	100	0/4		Toxic
	4	99	0/4		Toxic
	5	90	0/4		Toxic
	5·7	50	0/4		Toxic

* Log total cells = 6. † Killed at 68 days and no tumour found. ‡ Figures in parentheses are averages.

As is apparent from Table 2, admixture of sodium lauryl sulphate caused an inhibition of tumour formation which is roughly comparable to the increased ability of the cells to take up dye, although there is more than a ten-fold difference in the minimum number of unstained ('viable') cells necessary to produce ascites. In contrast, when the non-ionic surfactant 'Igepal *DM*-710' (a polyoxyethylated nonylphenol of molecular weight approximately 1300) was employed, no tumours were observed at the end of 68 days, even when the final concentration of unstained cells was 500,000. Cells treated with lauryl pyridinium chloride proved toxic to the animals. 10-Hydroxydecenoic acid, in citrate buffer of *p*H 5·5, permits only 37 per cent of the cells to pick up dye (acid concentration 3 mgm. per ml.).

At *p*H 4·3 in phosphate buffer, initially 10 per cent of the cells stained. The figure was not changed immediately by addition of 10-hydroxydecenoic acid, but after 20 min. 70 per cent of the cells exhibited staining. Morphologically, there was no lysis. The cells were wrinkled yet intact as compared to the loss of cytoplasm after treatment with sodium lauryl sulphate or 'Igepal *DM*-710'. Details of these changes will be reported elsewhere.

Attempts were made to inhibit tumour-growth *in vivo* by intraperitoneal administration of sodium lauryl sulphate and '*DM*-710'. Mice were injected with 10^6 cells. One week later all the ascitic fluid obtainable was removed by syringe aspiration. Each mouse was injected with 1 ml. 0·014 *M* surfactant. Samples of ascitic fluid were withdrawn 24 hr. later, and nigrosin uptake determined. The controls and animals treated with sodium lauryl sulphate showed 3 per cent dye uptake; the '*DM*-710' treated, 12 per cent. The control animals died in an additional eight days (average), those treated with sodium lauryl sulphate in four, and those treated with '*DM*-710' in two. All had typical tumour at autopsy.

In view of the results obtained to date, it appears that while inhibition of tumour growth can be obtained with a number of agents, the mode of action of these substances differs. One might speculate that some agents act by altering the cell surfaces, while others may complex vital proteins, inhibit enzymes, or interfere with fatty acid metabolism. It is obvious that alterations in the ability of cells to take up dye are not always correlated with death of the cells[5].

This work was supported in part by grants from the U.S. Public Health Service (*CY*-3475(C2)), Damon Runyon Memorial Fund (*DRG*-426*A*) and the Leukemia Society, Inc. Surfactants were gifts from E. I. DuPont de Nemours and Co., Antara Chemicals and Hooker Chemical Co. The 10-hydroxydecenoic acid was a gift from Prof. Butenandt of Munich.

M. E. Hodes
Aaron K. Warren
Catherine Gardella Palmer

Tumor Research and the
Department of Medicine,
Indiana University Medical Centre,
Indianapolis 7, Indiana.

[1] Townsend, G. F., Morgan, J. F., and Hazlett, B., *Nature*, **183**, 1270 (1959).
[2] Townsend, G. F., Morgan, J. F., Hazlett, B., Shuel, R. W., and Tolnai, S., *Proc. Amer. Assoc. Cancer Res.*, **3**, 69 (1959).
[3] Hodes, M. E., Palmer, C. G., and Williams, D. S., *Nature*, **182**, 529 (1958).
[4] Hodes, M. E., Palmer, C. G., and Warren, A. K., *Exp. Cell Res.* (in the press).
[5] Eaton, M. D., Scala, A. R., and Jewell, M., *Cancer Res.*, **19**, 945 (1959).

ANATOMY

Intracellular Canals in Human Sweat Glands

Hibbs[1] has demonstrated the existence of intercellular canaliculi in human eccrine sweat glands by electron microscopy and found them to be situated in the coiled secretory portion of the glands only. He was unable to recognize intracellular canaliculi, however. These intercellular canaliculi can be seen from his illustrations to be lined by a plasma membrane which shows many micro-villi projecting into the lumen. This lumen contains a moderately homogeneous matrix of low density and several indistinct granular profiles, possibly in the nature of a secretion.

The present communication describes the finding of structures resembling intracellular canaliculi in human eccrine sweat glands. As in Hibbs's cases these were found in the coiled secretory portion of the gland. But in contrast to those in his cases, which were from adult Negro volar skin, they were found in the abdominal skin of a 5-year-old white girl; the biopsy being taken immediately on making the incision for a nephrectomy.

The appearances of these structures are exemplified by that shown in Fig. 1. The lumen (*X*) can be seen to be surrounded by a plasma membrane folded into many micro-villi. It also contains a low-density matrix and several more dense but ill-

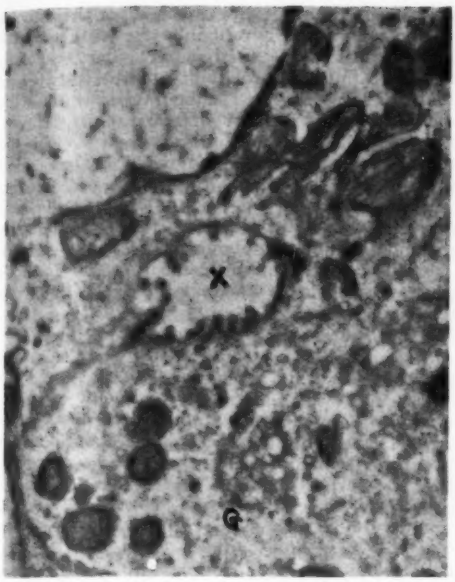


Fig. 1. Electron micrograph of a secretory cell of a human eccrine sweat gland (abdominal skin). The structure (*X*) shows the typical appearances of an intercellular canal, but lies wholly within the cytoplasm. The adjacent structure (*G*) is the Golgi complex. (Palade's osmium tetroxide fixative. × 10,800)

defined granular profiles. These appearances are virtually identical with those reported by Hibbs. It can also be seen from the illustration that the structure lies wholly within one cell. That is to say, cell boundaries are not seen anywhere near it, nor more importantly, are any contiguous with its limiting membrane. It is of interest, and may also be of significance, that it is lying close to the vesicular profiles of the Golgi complex (*G*).

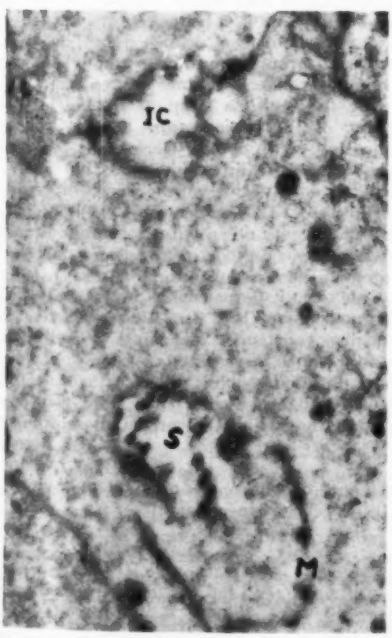


Fig. 2. A different part of the same sweat coil depicted in Fig. 1. *IC*, intercellular canal; *S*, intracellular sinus or canal; *M*, double membrane with desmosomes. (Palade's osmium tetroxide fixative. × 13,400)

In Fig. 2 can be seen an intercellular canaliculus (*IC*) together with a similar structure (*S*) apparently lying entirely within the cytoplasm of the cell. That this is not a true intracellular canaliculus is suggested by its close proximity to the double cell membrane (*M*), which can be seen to possess desmosomes.

By definition a canaliculus must commence and end somewhere. It may be that the structure described here joins two intercellular canaliculi or joins an intercellular canal to the lumen of the coil. On the other hand, it might take the form of a blind sinus, communicating at one end with the lumen or with an intercellular canal, the blind end lying wholly within the cytoplasm.

It has not yet been possible to decide whether these structures are intercellular canaliculi or merely blind sinuses, or whether they are permanent or temporary.

I wish to thank Dr. I. Friedmann and the Institute of Otology, University of London, for putting the facilities of their electron microscope at my disposal.

T. G. Scott

Department of Morbid Anatomy,
The Hospital for Sick Children,
Great Ormond Street,
London, W.C.1.

[1] Hibbs, R. G., *Amer. J. Anat.*, **103**, 201 (1958).

Lymph Node Reactivity to Homografts of Cancellous Bone

N. A. Mitchison[1] first showed that the power to transfer immunity caused by lymphosarcoma 6*C3HED* to non-susceptible mice is confined to the lymph nodes draining the site of implantation. Billingham *et al.*[2] also found that in mice the tissues of the host which have the power to transfer immunity to skin homografts are the regional nodes and to a lesser degree the spleen. Gallone[3] and his colleagues had previously shown that an increase in pyronin-staining cells occurred in the lymph nodes draining skin homografts. This work was confirmed and extended by Scothorne and McGregor[4], who showed that in rabbits a considerable increase in weight occurred in lymph nodes draining homografts, but not autografts, of skin. Further, they showed that after homografting, great accumulations of 'large lymphoid cells' appeared in the cortex and to a lesser extent in the medullary cords of the draining lymph nodes. The cellular response waned rapidly with the onset of graft destruction, and within two days the nodes were largely depleted of pyroninophilic elements. Radici and Piredda[5], also using rabbits, have described how, five days after a skin homograft, the reticular cells of the medullary cords of the first regional node are in large part replaced by pyroninophilic cells. Craigmyle[6], however, using cartilage, was able to show that the weight changes and cytological alterations in the regional lymph nodes occurred, but only in response to second-set homografts and first-set heterografts of cartilage. He concluded that cartilage in the rabbit is only mildly antigenic.

The reaction of the first regional lymph node to a constant weight (95–100 mgm.) of fresh cancellous bone removed from the ilium of five albino rabbits

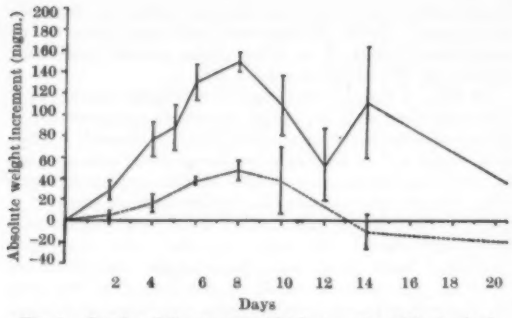


Fig. 1. Graphs of the mean weight increments, with standard errors, of the first regional lymph nodes after homografts (——) and autografts (– – –) of cancellous bone

and inserted into the subcutaneous tissue of the ear in fifty-one Flemish Giant rabbits has been investigated. Control animals were provided by nineteen Flemish Giants which received autografts of cancellous bone into the subcutaneous tissue of the ear. The animals were killed at intervals of 2–21 days after operation. The first regional lymph nodes on both sides were removed, weighed and fixed in Carnoy's fluid, embedded in paraffin, cut at 6μ and stained with methyl green-pyronin.

The mean weight increments and standard errors of the first regional lymph nodes for the homografted and the autografted animals at various time-intervals after grafting are shown in Fig. 1. An overall test of the difference between the homograft nodes on one hand, and the autograft nodes on the other, has been made by combining the values of P for each time-interval, using the method described by Fisher[7]. This test of significance gave $P < 0{\cdot}005$, showing that overall, the difference in mean weight increments of the homografted and the autografted nodes was highly significant.

Histological examination of the lymph nodes reacting to bone homografts has revealed great numbers of pyroninophilic large and medium lymphoid cells in the diffuse cortical tissue and in the medullary cords. Further analysis of the nodes has shown a sectoral distribution (Fig. 2) of these pyroninophilic cells which is probably due to the entry of the 'homograft factor' to that particular part of the cortex. To put this probability to the test, 0·1 ml. indian ink was injected subcutaneously into the ear on the ventral aspect in two rabbits, 1 centimetre from the external auditory meatus. The first regional lymph nodes were removed ½ hr. later, fixed, embedded and sectioned. Indian ink was found to be distributed to only one side of the nodes. Hence the conclusion that the sectoral distribution of the large and medium lymphoid cell response is due to the localized entry of antigenic material from the bone homograft to a particular part of the lymph node appears justified.

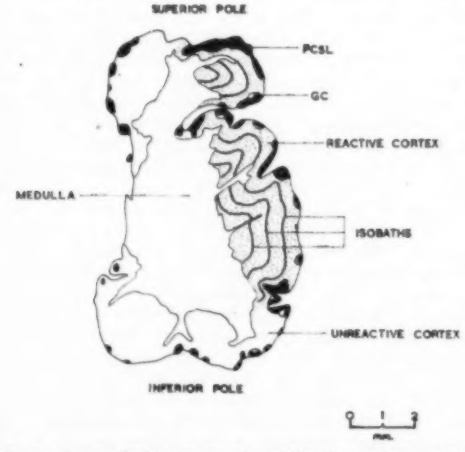


Fig. 2. Camera lucida tracing of a section from a first regional lymph node removed four days after homografting. The distribution of large and medium lymphoid cells in the cortex is shown by stippling. The method of selective sampling of the reactive cortex is indicated by the isobaths. (*GC* = germinal centre; *PCSL* = peripheral collection of small lymphocytes)

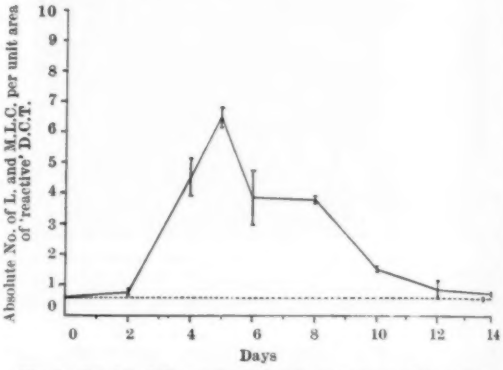


Fig. 3. Graphs of the means, with standard errors, of the counts of large and medium lymphoid cells in the reactive diffuse lymphoid tissue of the cortex from normal (– – –) and homografted (——) lymph nodes

A quantitative analysis of the large and medium lymphoid cell response has been attempted in the reactive sectors of the diffuse lymphoid tissue of the cortex in twenty-four nodes removed 2–14 days after homografting. Counts have been made in three different sections from each node in fields of 57μ², using × 10 eyepieces and a × 100 oil immersion objective. The counts were made two graticule divisions apart on lines (or isobaths) four, eight and less frequently twelve, graticule divisions from the surfaces of the nodes (Fig. 2). The mean number of large and medium lymphoid cells per unit area of reactive cortex for three nodes at each time-interval has been found to rise rapidly and reach a maximum between the fourth and sixth day after homografting (Fig. 3). A more gradual decline then ensues, the count returning to a normal level by the fourteenth day after insertion of the graft.

A more detailed account of these results will shortly be published together with the results of an immunological examination of the sera of these animals.

R. G. Burwell
G. Gowland

Departments of Anatomy and Bacteriology,
The University,
Leeds.

[1] Mitchison, N. A., *Proc. Roy. Soc.*, B, **142**, 72 (1954).
[2] Billingham, R. E., *et al.*, *Proc. Roy. Soc.*, B, **143**, 58 (1954).
[3] Gallone, L., *et al.*, *Arch. Atti Soc. Ital. Chir.*, **2**, 329 (1952).
[4] Scothorne, R. J., and McGregor, I. A., *J. Anat.* (Lond.), **89**, 283 (1955).
[5] Radici, G., and Piredda, A., *Giornale Ital. di Dermat.*, **1**, 49 (1957).
[6] Craigmyle, M. B. L., *J. Anat.* (Lond.), **92**, 75 (1958).
[7] Fisher, R. A., "Statistical Methods for Research Workers", tenth ed. (Oliver and Boyd, 1946).

BIOPHYSICS

Automatic Equipment for the Collection and Processing of Data from Geiger-Müller Counters

During a radioisotopic investigation of ion accumulation processes in marine algae it became apparent that a considerable amount of data required to be collected over extended periods of time. Automatic equipment was therefore devised both for the collection and preliminary processing of the information.

Geiger counters (type *GM*4) with their aluminium end-windows protected by epoxy-resin paint are fixed directly above algal sections contained in shallow cavities through which seawater incorporating the radioisotope being studied is rapidly circulated. (A description of the section holder and circulator assemblies is being submitted for publication elsewhere.) The voltage pulses from probe units to which sets of the Geiger counters are sequentially connected are recorded on a standard tape recorder at a tape speed of $1\frac{7}{8}$ in. per sec., the frequency response at this speed being adequate to record without loss of counts from a probe unit with 500 μsec. paralysis time. The number of Geiger counters in a sequence, the periods for which counts are taken and the interval between successive count periods can be pre-set on a programming unit. As the tape recorder motors are switched on only for a duration determined by the programming unit (in practice 1 min. longer than the count period) a single spool of tape can accommodate large numbers of count periods, for example, a 2,400-ft. spool can permit the recording of more than 120 sets of counts of 1-min. duration on each of its two tracks. Originally the reproduction of this data in usable form was a time-consuming task despite the utilization of a playback speed eight times that of recording, but recently a simple data-processing machine has been completed.

The pulses replayed from the two tracks of the magnetic tape are fed into two scalers each provided with dividing circuits, the division ratios corresponding to the times for which the original counts were recorded. The scalers thus indicate directly the counts per minute on their main registers. Each scaler has a subsidiary register on which the dead-time correction factor is automatically computed. On receipt of a signal which is recorded on the tape at the end of each count period and which is isolated by a two-stage frequency-selective network, a read-out and print-out sequence is initiated. In addition to printing out the counts per minute and the dead-time correction factors, a solenoid-operated calculating machine also prints the starting count per minute for each Geiger counter selected in the original sequence together with counter identification numbers. The calculating machine can perform simple operations on the data being printed out such as producing automatically a difference between the newly determined count per minute and starting count per minute. In the majority of cases, this difference is sufficiently satisfactory for direct graphical representation to indicate the course of an experiment without the application of the dead-time correction factor though, if required, the data for dead-time correction are immediately available without reference to tables. On completion of the print-out sequence the scaling and computing circuits are automatically reset.

This simple computing equipment, while designed specifically to deal with tape-recorded data, can be used with advantage for routine Geiger counting wherever large numbers of samples have to be dealt with and is thus felt to be of wider interest.

I am grateful to the Extra-mural Research Section of the United Kingdom Atomic Energy Authority for financial assistance in the construction of the equipment and for permission to publish this description.

Richard Scott

Biophysics Department,
King's Buildings,
West Mains Road,
Edinburgh, 9.

Identification of Ultracentrifugal Components in Human Plasminogen Preparations

Samples of human plasminogen, prepared according to the method of Kline[1], have been subjected to ultracentrifugal analysis[2]. The patterns observed contained two sedimenting peaks. The slower peak constituted approximately 70 per cent of the total area and had a sedimentation constant, $s_{20,w}$, of 4·28 *S*, extrapolated to infinite dilution. The faster peak, which was much broader and resolved poorly from the main component, had a sedimentation constant of about 7–10 *S*. It was merely assumed that plasminogen was to be identified with the 4·3 *S*-component, and on this basis, along with other data, molecular size and shape were estimated. We now report direct evidence to substantiate this assumption.

The proteolytic activity was measured by casein assay, essentially according to Remmert and Cohen[3], except that the casein concentration was 2 instead of 4 per cent. The concentration of protein in the sample being assayed was measured by light absorption at 2800 Å., using 14·0 as extinction coefficient[3]. The activity is therefore expressed as casein units/mgm. protein.

Sedimentation studies were made in a Spinco model *E* ultracentrifuge, using an analytical cell with a 2° sector to minimize the volume required, and a standard fixed-partition cell for separation of components. These runs were made on samples that had been dialysed against acid-saline (0·15 *M* sodium chloride + 0·01 *N* hydrochloric acid, *p*H 2).

In an early separation experiment, a solution at 1·4 per cent concentration was run in the separation cell until the fast component had apparently gone past the partition. After terminating the run, samples were obtained from the top compartment ('Top') and the bottom compartment ('Bottom'), 0·2 ml. each, and diluted with 1·5 ml. of acid-saline. These dilutions were measured for protein content and assayed on casein. A sample of the initial solution was allowed to stand at room temperature during the run ('Warm control') and another solution was kept refrigerated ('Cold control'). These were similarly diluted and assayed. The results are shown in Table 1. This experiment is adequate proof that the proenzyme is to be associated with the slow component. If it were in the fast peak, the activity in 'Top' should be considerably reduced, although not to zero, since the boundary is quite broad; instead

Table 1. Proteolytic Activity of Human Plasminogen and Ultracentrifugal Fractions

Sample	Specific activity (units/mgm.)
Cold control	3·9
Warm control	3·5
Top	6·6
Bottom	3·9

Table 2. Proteolytic Activity and Ultracentrifugal Analysis of Human Plasminogen and Ultracentrifugal Fractions

Sample	Specific activity (units/mgm.)	Relative amount of 4·3 *S*-component (per cent)
Warm control	4·4	70·2
Top	7·8	93·6
Bottom	7·1	88·8

it is increased, as would be expected from removal of inert proteins.

The experiment was repeated, however, with results that were equivocal, as was true in several additional trials. The problem seemed to be due to the difficulty of judging the proper degree of dilution to avoid a protein-level that was too low (poor sensitivity) or too high (non-linearity) for the casein assay. I decided to perform a series of separation runs, in order to pool the respective products. There would thus be enough material to be checked by analytical ultracentrifugation. A group of six separation runs were pooled and yielded 1·96 ml. of 'Top' and 1·07 ml. of 'Bottom'. The sedimentation pattern of the initial sample is shown in Fig. 1. On re-examining the fractions, at similar concentrations, sedimentation patterns as in Fig. 2 were observed. The measured proportions for these samples are shown in Table 2, along with the assay data. It can be seen that 'Top' does contain considerable enrichment of slow peak, and even 'Bottom' shows a similar enrichment. Both fractions show an increased specific activity, fully in accord with the first experiment. In fact, if one plots casein activity for these three samples against percentage of 4·3 *S*-component, a quite acceptable straight line is observed. One can conclude, therefore, that the fast peak represents an inert contaminant. In addition, it is seen that a purification of about 1·8-fold can be achieved by ultracentrifugation. Studies of fractionation with ammonium sulphate, leading to similar conclusions, as well as to electrophoretic identifications, will be published elsewhere.

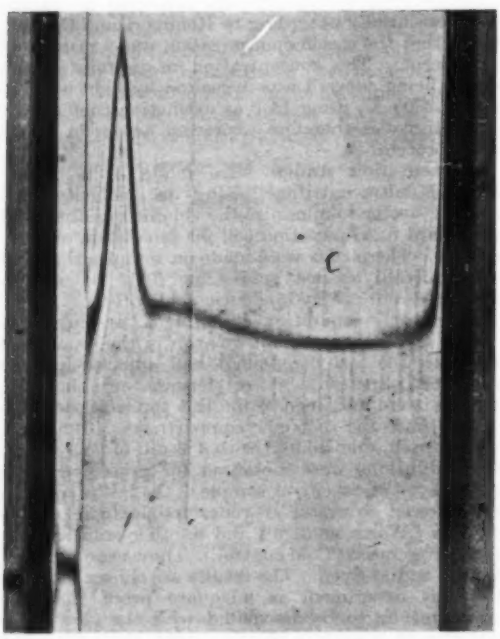


Fig. 1. Ultracentrifugal pattern of human plasminogen (by Kline method). Concentration of protein, 0·80 per cent; bar angle, 40°; photograph at 16 min.; rotor speed, 59,780 r.p.m.

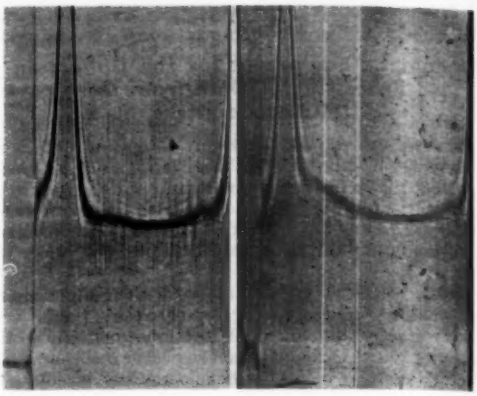


Fig. 2. Ultracentrifugal pattern of human plasminogen fractionated in separation cell. 'Top' fraction on left. Concentration of protein, 0·88 per cent; bar angle, 40°; photograph at 20 min. 'Bottom' fraction on right. Concentration of protein, 0·80 per cent; bar angle, 40°; photograph at 20 min.; rotor speed, 59,780 r.p.m.

Technical assistance was provided by Mr. Ivan Kavai. This investigation was supported in part by a research grant, *H*-1792, from the National Heart Institute, Public Health Service, and also by a Senior Research Fellowship (*SF*-118) from the Public Health Service.

Sidney Shulman

Department of Biophysics,
University of Buffalo,
School of Medicine,
Buffalo, New York.

[1] Kline, D. L., *J. Biol. Chem.*, **204**, 949 (1953).
[2] Shulman, S., Alkjaersig, N., and Sherry, S., *J. Biol. Chem.*, **233**, 91 (1958).
[3] Remmert, L. F., and Cohen, P. P., *J. Biol. Chem.*, **181**, 431 (1949).

BIOLOGY

Surface of a Parasite and the Hæmocytic Reaction of its Host

Experiments recorded in a recent paper[1] have shown that the hæmocytic reaction of insects to parasites and other foreign bodies in their hæmocœl is stimulated by properties of the surfaces of those objects. In an article[2] the publication of which has been delayed, I have brought together observations which suggest that the hæmocytes of an insect react to any surface which lacks specific properties of the surfaces which they themselves lay down, or contribute to, about the organs and tissues of the insect of which they form part.

If that hypothesis is correct, a foreign body that has caused a reaction and has been encapsulated by blood cells might be expected thereby to have acquired a surface that would render it immune to further reaction from the same or a similar host. That this is so was demonstrated[1] by implanting an object in the hæmocœle of an insect and, after it had been encapsulated, transferring the object and the unbroken capsule about it to another host. Objects thus transplanted to individuals of the same species evoked no visible response; those transplanted to hosts of a different kind stimulated another hæmocytic reaction which led to the encapsulated object being enveloped in a second capsule formed by the blood cells of the second host.

The hypothesis has recently been tested in the reverse way, by altering a surface that confers immunity to the reaction and finding that the reaction then takes place. It is well known that living larvæ of the parasitoid *Nemeritis canescens* stimulate no reaction on the part of the hæmocytes of their normal host, *Ephestia sericarium*, so long as their surface is unbroken; although, if their surface is minutely perforated, as by the mandibles of a competing parasite, hæmocytes of the host congregate locally about the wound. These larvæ therefore provide suitable material for examination of an immune surface. When first-instar larvæ of *Nemeritis* were put individually into a variety of fluids, removed and washed for some hours in insect saline, and then implanted in *Ephestia*, two groups of significant results were observed. After immersion in some fluids, the implanted parasites evoked no reaction, but fed and developed normally in their new hosts. After immersion in other fluids, however, the implanted living parasites provoked a hæmocytic reaction in their normal hosts and were found completely covered in a thick layer of hæmocytes. Within that layer they were still alive and moving vigorously as though attempting to divest themselves of the hæmocytic covering.

Various fluids have been used in experiments of this pattern, the period of immersion in them being adjusted to allow survival of the parasite larvæ. So far as the experiments have yet gone, all the fluids found to have the second result, that is, to expose the parasite to encapsulation in its normal host, have been solvents of fats. Octane has been found especially efficient. It appears from these observations that the removal of a lipid constituent of the surface of *Nemeritis* larvæ also removes the specific properties that provide its immunity to the hæmocytic reaction of *Ephestia*.

A few parallel experiments have been carried out using testes of *Ephestia* for implantation. As is common knowledge, if these organs are removed from an insect and implanted in another individual of the same species, they evoke no general hæmocytic reaction; but if implanted in quite different hosts they are encapsulated. When entire *Ephestia* testes were immersed in fluids found to be effective in the experiments with *Nemeritis* larvæ, washed in saline, and implanted in other *Ephestia*, they were encapsulated. These experiments give direct support to the hypothesis put forward, but are not as critical as those involving parasite larvæ because it is not easily possible to observe whether the encapsulated testes are sound and healthy. It is the fact that larvæ of *Nemeritis* can be retrieved from *Ephestia* alive and vigorous although encapsulated that makes them so useful as experimental objects for examining the surface properties that confer immunity to insect parasites in their normal hosts.

A full account of this and related work will be published elsewhere.

George Salt

King's College,
Cambridge.

[1] Salt, G., *Proc. Roy. Soc.*, B, **151**, 446 (1960).
[2] Salt, G., in "The Cell and the Organism" (Camb. Univ. Press, 1961).

Gestation Time for Delayed Birth in the Quokka

Sharman[1] has established that normal gestation time for the Rottnest Island quokka (*Setonix brachyurus*) is twenty-seven days. He has further shown that, in delayed birth in this species, the unilaminar blastocyst stage at which development is arrested occurs about three days after copulation. It is of interest to assess the time necessary from resumption of development of the blastocyst to parturition after the impetus to growth, that is, removal of the initial joey, is applied.

A sample of 40 females with pouch young were caught on Rottnest Island. The joeys were removed and the females taken to the mainland where they were retained in isolation from males. The pouches were examined for the presence of a second joey on the days indicated in Table 1. From Table 1 it is seen that three joeys were born twenty-five days after the removal of the initial joeys, but the majority of births occurred on the twenty-sixth day. Taking twenty-six days as the further gestation time of the blastocyst, which had taken three days to achieve the stage at which development was arrested, it appears that the total gestation time for the 'delayed' joey is twenty-nine days. Since normal gestation time is twenty-seven days, it seems that two days are necessary for resumption of development of the quiescent blastocyst.

Table 1. Interval in Days between the Removal of the Initial Joey and the Birth of the 'Delayed' Joey

Day	23	24	25	26	27
No. of pouches examined	35	37	40	36	22
No. of joeys found	0	0	3	14	0

During the course of this experiment and other work data were collected on the sex of the initial joey and that of the subsequent 'delayed' joey. Table 2 shows no significant association between the sex of the initial and 'delayed' joeys. This is presented in confirmation of Sharman's finding that the 'delayed' joey is the result of a separate ovulation, and no process analogous to twinning occurs.

Table 2. Relationship between the Sex of the Initial Joey and that of the 'Delayed' Joey

		Initial joeys		
		Males	Females	Total
'Delayed' joeys	Males	3	7	10
	Females	5	8	13
		8	15	23

This work was supported financially by grants from the University of Western Australia and the Commonwealth Scientific and Industrial Research Organization.

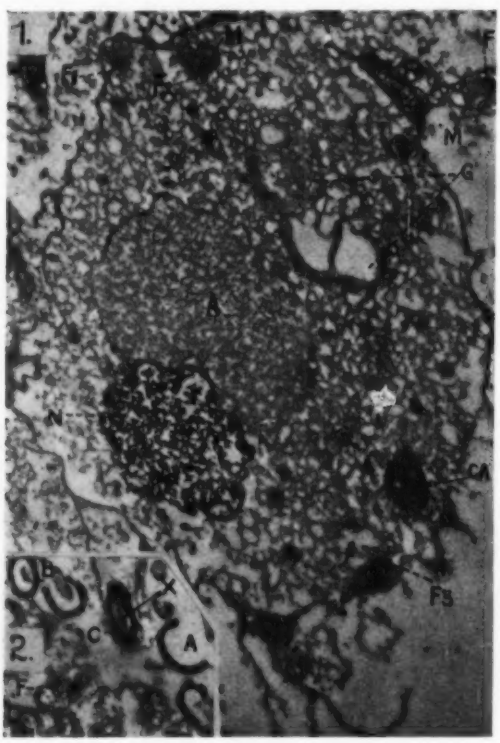
J. W. Shield
Patricia Woolley

Zoology Department,
University of Western Australia,
Nedlands, Perth.

[1] Sharman, G. B., *Aust. J. Zool.*, **3**, 56 (1955).

Electron Microscopy of Thysanuran Spermiogenesis

In a recent discussion[1,2] on the position of the acrosome and centriole in the thysanuran spermatozoon, the necessity for electron microscopy was stressed. In Fig. 1, the Golgi body (acroblast; *G*) is lying to one side of the very large acrosome (*A*). Below is the nucleus (*N*). The flagellum has grown out inside the cell and is cut across in three places (*F*1–3). On the right is a constantly occurring body (*CA*), which at present is considered to be a centriole adjunct, as in other micrographs it is found near the centriole. Cross-sections of the ripe or nearly ripe sperms are shown in Fig. 2. The anteriorly situated acrosome has become a scoop-shaped body (*A*), which passes back to form a tube (*B*), which joins the nucleus (*C*), which passes back to join the flagellum (*F*). No adnuclear thread or flagellum is found on the tubular nucleus, but there is an intranuclear body (*X*), which projects up into the funnel of the acrosome. This is probably what is seen with the light microscope in the form of an intra-nuclear flagellum. This body, however, does not possess the flagellar ultrastructures.



Figs. 1 and 2

A fuller account of this spermiogenesis, and that of *Lepisma*, will be published elsewhere. I thank M. Jean André of the Electron Microscopy Department of the Institut de Recherches sur le Cancer, Villejuif (Seine), for taking the micrographs.

R. S. Mathur

Trinity College,
Dublin.

[1] Nath, V., Gupta, B. L., and Mittal, L. C., *Nature*, **186**, 899 (1960).
[2] Gatenby, J. B., and Mathur, R. S., *Nature*, **186**, 900 (1960).

Influence of Amino Triazole on the Chloroplast Pigments of Wheat Seedlings

3-Amino-1,2,4-triazole is a chemical which has several effects on higher plants. It is a growth inhibitor, and has been used on cotton plants as a defoliant[1]. Hall *et al.* demonstrated that tissues formed subsequent to application of this chemical have a decreased chlorophyll content, while the chlorophyll-level of already mature tissues is unaffected. It was not entirely clear to these investigators whether the observed effect of amino triazole on chlorophyll content is due to chlorophyll destruction or to interference with chlorophyll synthesis. The structural similarity of the triazole ring to the pyrrole rings of chlorophyll prompted the suggestion that amino triazole brings about a block in chlorophyll synthesis prior to the protochlorophyll stage by a competitive inhibitory mechanism[1]. This concept was somewhat strengthened when it was found that levels of catalase, which has a similar structure, were also decreased in both plants and animals by treatment with amino triazole[2,3].

Experiments with *Elodea canadensis* further served to localize the effect of amino triazole as influencing chlorophyll synthesis rather than chlorophyll destruction, but microscopic observations clearly indicated interference with plastid development[4]. This suggested the possibility that the influence of amino triazole on chlorophyll content might be secondary to an effect on the development of the plastid as a whole. According to Pyfrom *et al.*[3], "a small amount of amino triazole interferes with the plastids during leaf formation or differentiation, and chlorophyll *as well as other plastid pigments* are always low in these leaves".

In an effort to secure further insight into this situation, wheat grains were germinated and seedlings were grown in Petri dishes containing filter paper, moistened with water or with various concentrations of amino triazole. The conditions of growth were identical with those described by Haber and Luippold[5] with 400–500 ft.-candles of white light during a 16-hr. day. Analyses for chlorophyll *a*, chlorophyll *b*, and total carotenoids were performed according to the technique of Röbbelen[6]. After preliminary trials with various concentrations of amino triazole, a concentration of 10^{-4} *M* was selected, which permitted about 70 per cent of normal growth during a 12-day period, yet reduced the chlorophyll content to a value approximating 5 per cent of normal.

Wheat seedlings were germinated in darkness, in either 10^{-4} *M* amino triazole or in water. After 6 days, the etiolated seedlings were placed under a light source of the type described by Withrow and

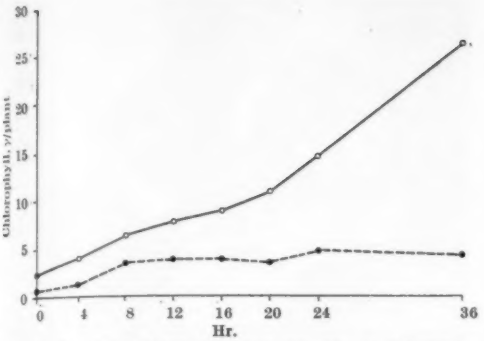


Fig. 1. Greening of 6-day old wheat seedlings, as influenced by 10^{-4} *M* amino triazole. ——, Control; – – –, amino triazole

Elstad[7], which provided a light intensity of 1,000 ft.-candles. Determinations of total chlorophylls (*a* plus *b*) were made at intervals during the subsequent 36 hr. The results (Fig. 1) indicate that normal greening was drastically inhibited by this concentration of amino triazole.

In another type of experiment, wheat seedlings were grown in water under the usual 16-hr. photoperiod. After 6 days, the water in some of the dishes was replaced by 10^{-4} *M* amino triazole, and all the plants were placed in darkness. Chlorophyll estimations were made at 2-day intervals over a period of 10 days. The findings (Fig. 2) indicate no difference in the rate of chlorophyll disappearance in darkness as a result of treatment with amino triazole.

Wheat seedlings were grown in water under a 16-hr. photoperiod for 6 days, and were then transferred to 10^{-4} *M* amino triazole. When such plants were continued under the 16-hr. photoperiod, their subsequent appearance was very striking. The basal portion of the leaves was a normal green in colour. Distal to the green area was a colourless zone about 1 cm. in length, while the portions of the leaves produced after treatment with amino triazole were a reddish-purple in colour, owing to the abundant production of an anthocyanin pigment, which was not detected in untreated plants. Further, this effect was not noted in plants treated similarly, but placed in darkness following treatment with amino triazole.

Wheat grains were germinated in the presence of amino triazole in concentrations ranging from 1×10^{-5} *M* to 2×10^{-4} *M*. After 12 days of growth under the usual 16-hr. photoperiod, analyses for total carotenoids and chlorophyll were made. The results (Table 1) indicate that the reduction in chlorophyll content resulting from treatment with amino triazole is accompanied by reductions of similar magnitude in the carotenoid pigments.

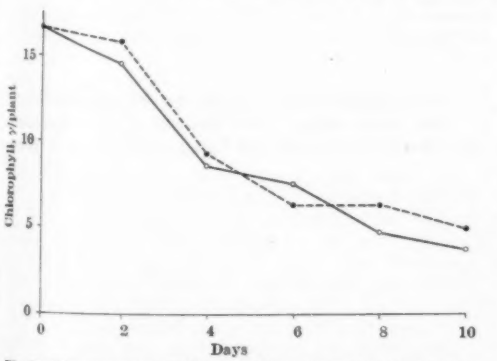


Fig. 2. Disappearance of chlorophyll from 6-day old wheat seedlings, in darkness, as influenced by 10^{-4} *M* amino triazole. ——, Control; – – –, amino triazole

Table 1. Pigment Content of Wheat Seedlings grown for 12 days in Various Concentrations of Amino Triazole

Concentration of amino triazole	Height (mm.)	Chlorophyll/plant (γ)	Carotenoids/plant (γ)
0 (Control)	105·2	56·6	12·7
1×10^{-5} *M*	98·9	46·8	11·0
2×10^{-5} *M*	93·8	26·8	6·7
4×10^{-5} *M*	77·5	7·3	1·3
1×10^{-4} *M*	72·1	2·0	0·5
2×10^{-4} *M*	38·3	1·7	0·3

In summary, the greening experiment indicates that the net rate of chlorophyll synthesis (excess of synthesis over destruction) is drastically reduced by amino triazole. There would appear to be no direct action of amino triazole on the rate of chlorophyll destruction, at least in darkness. Considered together, these findings would appear to add further evidence to that of earlier investigators[1,4] localizing the effect of amino triazole on the synthesis of chlorophyll. But since amino triazole has a similar influence on the levels of both carotenoids and chlorophyll: (1) the hypothesis of Hall *et al.*[1] which considers amino triazole as a competitive inhibitor of chlorophyll synthesis is incorrect, and (2) it would seem reasonable to suppose, confirmatory of earlier findings[3,4], that the effects of amino triazole on plastid pigments are secondary to an effect upon the plastid itself.

Frederick T. Wolf

Department of Biology,
Vanderbilt University,
Nashville, Tennessee.

[1] Hall, W. C., Johnson, S. P., and Leinweber, C. L., Bull. 789, Texas Agric. Exp. Sta., 15 (1954).
[2] Heim, W. G., Appleman, D., and Pyfrom, H. T., *Amer. J. Physiol.*, **186**, 19 (1956).
[3] Pyfrom, H. T., Appleman, D., and Heim, W. G., *Plant Physiol.*, **32**, 674 (1957).
[4] Linser, H., and Kiermayer, O., *Planta*, **49**, 498 (1957).
[5] Haber, A. H., and Luippold, H. J., *Amer. J. Bot.*, **47**, 140 (1960).
[6] Röbbelen, G., *Z. indukt. Abstamm.- u. Vererbungslehre*, **88**, 189 (1957).
[7] Withrow, R. B., and Elstad, V., *Plant Physiol.*, **28**, 334 (1953).

Complex Particles in *Hevea* Latex

Latex freshly tapped from *Hevea brasiliensis* is known to contain particles other than rubber. By high-speed centrifugation, Cook and Sekhar[1] parted such latex into a top fraction and a bottom fraction with serum between. Both fractions are visibly heterogeneous, and Moir[2] has recently distinguished no less than eleven zones in centrifuged latex. Only three types of particle have been described in the literature so far. These are the rubber particles, often pear shaped, found in the top fraction, the Frey Wyssling particles[3], which are yellow bodies found mostly in the lower part of the top fraction, and the 'lutoid' particles of Homans and van Gils[4]. The term 'lutoid' was originally applied to large irregularly shaped islands of a yellowish colour consisting of mainly non-rubber material and seen in whole fresh latex. Ruinen[5] detected a particulate structure in these islands and uses the term to describe individual globules seen therein. Schoon and Phoa[6] mention that "inside the lutoid vacuoles, in a few cases very

small particles are to be observed in Brownian motion". Up to date, no photographs of this phenomenon have been published.

I am at present carrying out an examination by microscopy of latex fractions separated after high-speed centrifugation. The technique of collection and centrifugation described by Moir[2] is used, the latex being tapped directly into a glass container surrounded by melting ice and the temperature kept below 5° C. throughout the preparative procedures. In such material from both mature and young trees, I have observed a distinct type of particle occurring abundantly in the bottom fraction from high-speed centrifugation, and forming the bulk of Moir's zone 8[2].

In the initial and intact state they are spheres of 2–10μ diameter. They have an external membrane which in a medium of suitable refractive index can be made transparent. The interior is fluid and contains very many smaller particles, in size from 1μ down to the lower limit of visibility. These small captive particles are in vigorous motion and can be seen to strike the containing wall frequently and to be deflected back into the interior (Fig. 1).

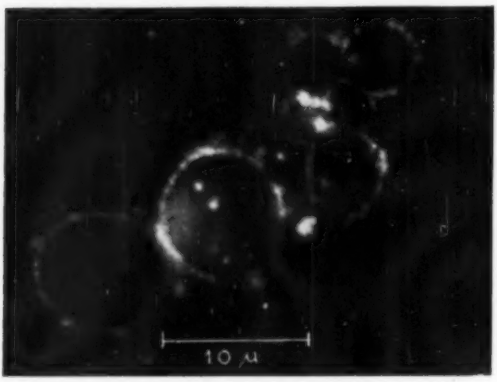


Fig. 1. A group of complex particles, slightly aggregated after centrifugation at 54,000*g*, resuspended in viscous ammonium polymethacrylate–water medium of refractive index 1·371. Photographed with Leitz 'Multblitz' electronic flash illuminant at 300 joules to arrest internal motion, using Reichert anoptral phase 100 × oil objective matched to Reichert variable phase condenser 'Polyphos'

After tapping, the particle membranes soon show signs of disintegration. Before this goes very far, the independent motion of the captive particles usually stops; they migrate to the walls and stick there. The membranes themselves readily adhere to each other to form loose agglomerates which later lose their definite internal structure and appear as confused irregular shaped masses.

These particles have also been observed in preparations of whole latex using an electron microscope (Fig. 2). This work was done in Germany using the following procedure to get a supply of fresh *Hevea* latex. A section of the trunk of a 3½-year-old clonal bud-grafted rubber tree (*RRIM* 603), approximately 1 m. long and 10 cm. diameter, was cut in Malaya and the ends were waxed. The specimen was sent by air to Germany sealed in polythene to reduce losses of moisture. Latex could be tapped for 10 days after the original cutting. Carl Zeiss (Oberkochen) provided laboratory facilities and the use of their Zeiss/*AEG EM*8 electron microscope.

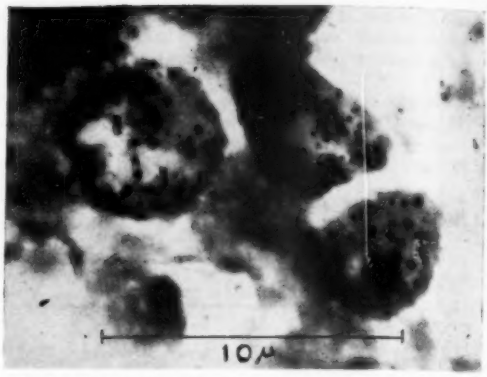


Fig. 2. Electron micrograph of a carbon pseudo replica from a smear preparation of latex taken with the Zeiss/*AEG* electron microscope at low magnification. An attempt was made to remove rubber particles by washing with benzene

The nature and function of these complex particles are not yet understood and are the subject of further investigation. Their appearance tallies with the description of Schoon and Phoa[6] for a type of lutoid; but in this case they are much more abundant than was supposed. Suggestions that rubber synthesis takes place within a plastid have long been current. For example, Milanez[7] described 'galactoplastids' in sectioned stained plant material from *Hevea brasiliensis*. Whether or not the particles now seen are related to the galactoplastids of Milanez, the existence of large numbers of such complex particles in latex has an important bearing on the controversy as to whether latex is whole cytoplasm or vacuolar sap and favours the first proposition.

I am indebted to Dr. Grehn and his co-workers at Leitz G.m.b.H., Wetzlar, for their invaluable advice on optical methods, also to Dr. Mahl of Carl Zeiss, Oberkochen/Württ., for his help with the electron micrograph, and to W. G. Wren and P. De Jonge for the preparation of the tree sample for dispatch to me in Germany.

W. A. Southorn

Rubber Research Institute of Malaya,
Kuala Lumpur.

[1] Cook, A. S., and Sekhar, B. C., *J. Rubber Res. Inst. Malaya*, **14** 163 (1953).
[2] Moir, G. F. J., *Nature*, **184**, 1626 (1959).
[3] Frey Wyssling, A., *Arch. Rubbercult.*, **13**, 392 (1929).
[4] Homans, L. N. S., and van Gils, G. E., Proc. Second Rub. Tech Conf. London, 292 (1948).
[5] Ruinen, J., *Ann. Bogoriensis*, **1**, 27 (1950).
[6] Schoon, Th. G. F., and Phoa, K. L., *Arch. Rubbercult.*, **33**, 195 (1956).
[7] Milanez, F. R., *Arquivos do Jardim Botânico de Rio de Janeiro*, **1** 39 (1951).

A Comparison of Three Methods for the Assessment of Fungal Colonization of Seedling Roots of Leek and Broad Bean

In recent years several methods have been devised for the isolation of fungi from root tissues. The Harley and Waid serial washing technique[1] has already provided valuable data on fungi closely associated with plant roots[2,3], but it has been suggested that the plating of washed root segments in this method does not always allow the isolation of slow-growing forms (such as Basidiomycetes), these being unable to compete with the faster growing fungi. Methods such as root maceration[4] and root fragmentation[5] have been claimed to provide a more

complete picture of root mycofloras. The experiments described here compare these three methods for the isolation of fungi from healthy seedling roots of leek (*Allium porrum* L.) and broad bean (*Vicia faba* L.).

Plants of both species were grown under greenhouse conditions in a grassland soil (*p*H 5·8) and were sampled 30–35 days after sowing. Before any isolations of fungi were attempted the roots were thoroughly washed, first in tap water to remove all visible soil particles and then in sterile water. Preliminary tests had shown that ten 2-min. washings with sterile water allowed efficient washing of the roots.

From this washed root material, isolation of fungi was attempted by the three aforementioned methods (plating of root segments, root maceration and root fragmentation). In all cases isolation of fungi was effected from similar lengths (20 cm.) of healthy root material. The three methods were applied in a manner which in all essential details was the same as that described by their respective authors[1,4,5]. For all methods Czapek-Dox + yeast extract agar (*p*H 5·0) was used as the isolation medium and all isolation plates were first incubated at 25° C. for three days and thereafter kept at room temperature, during which time isolation and identification of fungi were effected, and counts made of the number of fungal colonies arising from unit amounts of root material.

Table 1. Number of Fungal Isolates, per Unit Length of Root, obtained by the Use of Different Isolation Methods

Leek			Broad bean	
Root segment plating	Root maceration	Root fragmentation	Root segment plating	Root maceration
34 39	9 12	5 12	70 —	85 117

Results given in Table 1 indicate that, with leek, both root maceration and root fragmentation give fewer isolates from root material than does the direct plating of root segments. However, with broad bean this effect is not seen; in fact, root maceration provides more isolates than does the direct plating of root segments.

The results with leek (*Allium porrum* L.) are similar to those obtained by Timonin and Thexton[6] with roots of onion (*A. cepa* L.) and garlic (*A. sativum* L.). These authors attempted isolation and enumeration of root surface micro-organisms by plating dilutions of a suspension of root material obtained by shaking roots in sterile water containing glass beads (maceration of the root surface layers occurred). Their results showed that the number of fungi thus obtained was much less than those from dilution plates prepared from the rhizosphere soil of the same two plants.

It is possible that, with leek, chemical substances (possibly diallyl sulphides) possessing fungicidal or fungistatic properties are released during maceration or fragmentation; while the direct plating of root segments, which only causes a small amount of damage to the roots, causes little or no release of these substances. The results with broad bean show no evidence of any such inhibitory effects resulting from root maceration, although an unidentified substance fungicidal to *Aspergillus niger* has been reported[7] to be present in the stem and root of broad bean.

These results provide support for the suggestion[8] that maceration or fragmentation techniques, while probably useful for the isolation of fungi from the roots of many species, should be used with caution in view of the possible release of toxic substances during the disruption of the root tissues.

J. H. Clarke
D. Parkinson

Hartley Botanical Laboratories,
The University,
Liverpool.

[1] Harley, J. L., and Waid, J. S., *Trans. Brit. Mycol. Soc.*, **38**, 104 (1955).
[2] Stenton, H., *Trans. Brit. Mycol. Soc.*, **41**, 74 (1958).
[3] Peterson, E. A., *Can. J. Microbiol.*, **4**, 257 (1958).
[4] Stover, R. H., and Waite, B. H., *Phytopath.*, **43**, 700 (1953).
[5] Warcup, J. H., *Trans. Brit. Mycol. Soc.*, **42**, 45 (1959).
[6] Timonin, M. I., and Thexton, R. H., *Soil Sci. Soc. Amer. Proc.*, **15**, 186 (1951).
[7] Wain, R. L., *New Scientist*, **7**, No. 164, 41 (1960).
[8] Harley, J. L., in "Ecology of Soil Fungi" (University of Liverpool Press.)

ENTOMOLOGY

Number of Nymphal Instars of the Sugar-cane Froghopper

There was some disagreement among earlier authors as to the number of nymphal instars of the sugar-cane froghopper, *Aeneolamia varia saccharina* Distant (Homoptera, Cercopidae). Urich[1] and Williams[2] considered that there were four instars. Gough[3] and Kershaw[4] both stated that there are five instars; but from their descriptions it would appear that they each recognized a different series.

There are in fact five nymphal instars. This statement is based on the following evidence: (1) measurements of the head-widths of nymphs of all stages collected during one season in the field fall into five distinct groups; (2) the antennæ of nymphs in the five different head-width categories differ in size and structure; (3) more than 50 newly hatched nymphs were examined and were found to correspond to the first stage as determined by criteria (1) and (2); (4) two moults have been observed between the true first and second stages.

Table 1. Summary of Characters distinguishing the Five Nymphal Instars of *A. varia saccharina*

Instar	Total length (mm.)	Head-width (mm.)	Length of antenna (mm.)	No. of antennal segments
I	1·0–1·5	0·28–0·30	0·14	6
II	1·5–2·0	0·45–0·55	0·22–0·25	6
III	2·5–3·5	0·70–0·80	0·38–0·42	6
IV	4·0–5·5	1·15–1·25	0·60–0·75	6 or 7
V	6·0–8·0	1·65–1·75	1·25–1·40	6, 7 or 8

The characters which distinguish the five instars are summarized in Table 1.

Total length refers to the distance from the tip of the labrum to the tip of the abdomen. It varies with the state of development of the instar and is given here only as a general indication of size. Head-width is the distance between the outer lateral margins of the compound eyes. There are basically six antennal segments, but in the 4th instar the 5th segment, and in the 5th instar the 5th and 6th segments (counting from the base), are usually sub-divided each into two segments. The sub-division of these antennal segments may occur in one but not the other antenna of a single specimen.

Wing pad development may also be used to distinguish most of the stages, as the following key indicates.

(1)	No wing pads present	I and II instars
	Wing pads present	2
(2)	Wing pads on mesothorax only	III instar
	Wing pads on both meso- and meta-thorax	3
(3)	Wing pads scarcely longer than wide at the base	IV instar
	Wing pads distinctly longer than wide at the base	V instar

The five instars described here probably correspond to those recognized by Kershaw[4] although he did not give any detailed descriptions. Neither Williams[2] nor Urich[1] distinguished between the true first and second stage nymphs. Their descriptions of "second", "third" and "fourth" correspond to the true third, fourth and fifth instars. Gough[3] arrived at five instars by splitting the true fifth instar into two separate stages. He was probably misled by a change of appearance in the fifth instar a few days before moulting, due to the development of the adult cuticle and pigments within the nymphal exoskeleton.

D. W. Fewkes
Central Agricultural Research Station,
for
Caroni Limited, and Ste. Madeleine Sugar Co., Ltd.,
Waterloo Estate, Carapichaima, Trinidad.

[1] Urich, F. W., *Bull. Dept. Agric., Trin. and Tob.*, **10**, 177 (1910).
[2] Williams, C. B., *Mem. Dept. Agric., Trin. and Tob.*, **1**, 1 (1921).
[3] Gough, L. H., *Bull. Dept. Agric., Trin. and Tob.*, **10**, 5 (1911).
[4] Kershaw, J. C., *Bull. Dept. Agric., Trin. and Tob.*, **12** (73), 95 (1913).

Decreasing Photoperiod inhibiting Metamorphosis in an Insect

Anthrenus verbasci (L.) (Col. Dermestidae) has a two-year life-cycle (semivoltine) under outdoor temperature conditions in southern England, spending the first winter as a young larva and the second as a fully grown larva[1]. Under constant conditions in the laboratory larvæ may be either uni- or semivoltine according to temperature. The percentage of larvæ with a univoltine life-cycle increases from 0 at 15° C. to 100 at 25° C. The larvæ have been shown to possess an endogenous and persistent rhythm controlling the onset of diapause[2]. Each cycle of the rhythm consists of a period of active growth (with moulting and/or pupation) followed by diapause. Under constant conditions the length of the cycle is about 44 weeks, but this is extended to an annual cycle, under outdoor conditions, by the insertion of a period of dormancy after the completion of diapause.

The nature of this dormant period, and the agencies controlling it, were examined by rearing isolated larvæ: (1) under outdoor temperature conditions in a Stevenson screen and (2) under constant temperature conditions (20° C.). In both (1) and (2) 80 larvæ were kept in natural daylight and 80 in continuous darkness. There were two levels of relative humidity, 30 per cent and 70 per cent (with imperfect control when the temperature fluctuated). There were also two regimes of observation; half the larvæ were examined fortnightly and the ecdysed skins noted, while the other half were only examined immediately prior to the expected time of pupation. After this time, that is, from about the 20th week, both groups were examined weekly until the end of the experiment. The above differences in humidity and in frequency of observation did not affect the main result. Altogether 320 isolated larvæ were observed, but only those which successfully completed development are recorded in Fig. 1.

These experiments demonstrated the following points. First, under outdoor conditions, temperature was the important factor controlling the time of pupation—light appeared to play no part (Fig. 1 *A* and *B*). Secondly, under conditions of constant temperature and natural daylight the earliest pupations were delayed by periods up to about 13 weeks. This is shown by reference to the control experiments (Fig. 1 *D*) in which pupation commenced at the 64th week, whereas larvæ exposed to light (Fig. 1 *C*) were inhibited until the 76th week—the difference between *C* and *D* (13 weeks) is indicated by line *a*. (The narrowness of the range of pupation times in *A* and *B* compared with *D* reflects the fact that diapause was completed by all individuals in *A* and *B* before the temperature rose sufficiently to stimulate pupation. *C* can be regarded as intermediate in this respect.)

It would seem, therefore, that towards the end of a two-year cycle, larvæ which would in the absence of light pupate in October are inhibited from pupating until the following January, if they are exposed to natural daylight. Day-length is decreasing during this period, and this is thought to be the stimulus responsible for the inhibition of pupation.

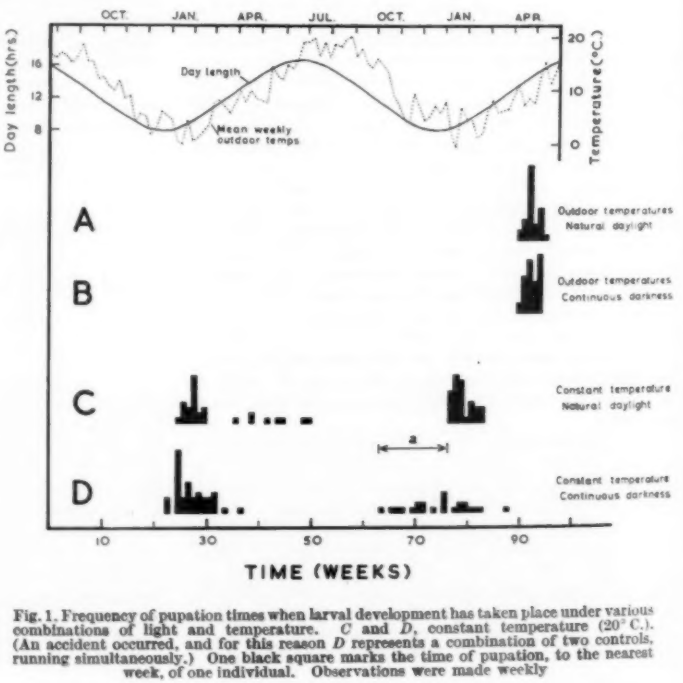


Fig. 1. Frequency of pupation times when larval development has taken place under various combinations of light and temperature. *C* and *D*, constant temperature (20° C.). (An accident occurred, and for this reason *D* represents a combination of two controls, running simultaneously.) One black square marks the time of pupation, to the nearest week, of one individual. Observations were made weekly

This type of response is of considerable ecological significance particularly in a semivoltine species. Since the amount of growth that takes place during an active period of the cycle is directly dependent on the temperature, larvæ developing over a period of two years, in habitats of widely different mean temperature, might reach the fully grown stage at almost any time of the year. A seasonal signal is therefore required to restrict emergence to the spring. Synchronized emergence is important for *A. verbasci*: since the adult life is relatively short, it greatly increases the chances of mating. This must be of considerable importance in areas where the population is small or thinly dispersed.

Anthrenus verbasci (L.) is the first insect in which it has been shown that metamorphosis is prevented during a period of decreasing day-length. Corbet[3] showed that diapause in the emperor dragonfly (*Anax imperator* Leach) was prevented by an increasing photoperiod. These two examples seem to be the only ones in which insects have been shown to be sensitive to a changing photoperiod rather than to one of fixed length.

G. M. Blake

Pest Infestation Laboratory
(Agricultural Research Council),
London Road,
Slough,
Bucks.

[1] Blake, G. M., *Bull. Ent. Res.*, **49** (4), 751 (1958).
[2] Blake, G. M., *Nature*, **183**, 126 (1959).
[3] Corbet, P. S., *Nature*, **175**, 338 (1955).

GENETICS

Evidence for a *Gm^{ab}* Allele in the Gm System of American Negroes

Rhesus-positive [Rh(+)] red blood cells coated with selected incomplete anti-D sera may be caused to agglutinate by serum from selected patients with rheumatoid arthritis[1]. The agglutinating activity of the rheumatoid arthritis serum may be inhibited by sera from some normal individuals[1]. Inhibiting normal sera are called Gm(+), non-inhibiting normal sera are called Gm(−). Four Gm factors detected by different pairs of rheumatoid arthritis and anti-D sera have been reported. They are Gm^a [1], Gm^b [2], Gm^x [3] and Gm-like [4].

In Europeans Gm^a and Gm^b are due to co-dominant alleles, *Gm* and *Gm^b* [2]. A third dominant allele at this locus, *Gm^{ax}* [3], determines the factors Gm^a and Gm^x. Table 1 lists the presumed genotypes for the phenotypes thus far observed among white populations. Family studies[2,3] support the postulated genotypes. The fourth factor, Gm-like, is absent or rare in Whites[4]. It occurs in American Negroes[4] and in Negroid populations from Java and Africa; but it has not been observed in pure Mongoloid populations[5]. Its genetic relation to *Gm^a*, *Gm^b* and *Gm^{ax}* is unknown[4].

Table 1. Phenotypes and Possible Genotypes for Gm^a, Gm^b and Gm^x in Caucasoids

Phenotypes	Presumed genotypes
Gm(a+ b+ x+)	*Gm^{ax}/Gm^b*
Gm(a+ b− x+)	*Gm^{ax}/Gm^{ax}*; *Gm^a/Gm^{ax}*
Gm(a+ b+ x−)	*Gm^a/Gm^b*
Gm(a+ b− x−)	*Gm^a/Gm^a*
Gm(a− b+ x−)	*Gm^b/Gm^b*

While only 56·96 per cent of 2,635 Europeans were found to be Gm(a+) (summarized from various reports in ref. 4), 95 per cent of 74 Eskimos[1], 100 per cent of 110 Negroids (Javanese, Djuka Negroes, Micronesians and West Africans)[5], 100 per cent of 105 Mongoloids (Eskimos, Athabascans, Oyana and Carib Indians)[5], and 100 per cent of 449 natives of Dakar[6] were found to be Gm(a +). Since *Gm^b* is an allele of *Gm^a* one would expect Gm^b to be absent among Negroids and Mongoloids with no white ancestry and rare among those with white ancestry. This communication is a report of our tests of this expectancy.

Sera from Baltimore populations of Negroes and Whites were tested at Johns Hopkins Hospital; sera from Cleveland populations of Negroes and Whites were tested at Western Reserve University. All tests were done on slides by the method reported by Harboe and Lundevall[3], with concentrations adjusted to suit the reagents used. The reagents are listed in Table 2. All tests were done with homozygous Rh(+) cells.

Table 2. Reagents used to test for Gm^a and Gm^b

Laboratory	To test for	RA	Anti-D
Johns Hopkins	Gm^a	B785	D4
	Gm^b	B30	D8
Western Reserve	Gm^a	Kimb.	Bowers
	Gm^b	Ham.	Bomb.

The results of the tests on the Negro and White populations are shown in Table 3. The phenotypic distributions in the samples from the two institutions agree within statistical limits ($P > 0{\cdot}5$, for the serum samples from Negroes, and $P > 0{\cdot}05$ for the serum samples from Whites).

Table 3. Tests of Serum from American Negroes and American Whites for Gm^a and Gm^b

A Negroes

Laboratory	No. tested	Gm(a+ b+) No.	Gm(a+ b+) %	Gm(a+ b−) No.	Gm(a+ b−) %	Gm(a− b+) No.	Gm(a− b+) %
Johns Hopkins	252	240	95·2	7	2·8	5	2·0
Western Reserve	371	353	95·1	7	1·9	11	3·0
Total	623	593	95·2	14	2·2	16	2·6

B Whites

	No. tested	Gm(a+ b+) No.	Gm(a+ b+) %	Gm(a+ b−) No.	Gm(a+ b−) %	Gm(a− b+) No.	Gm(a− b+) %
Johns Hopkins	143	61	42·6	14	9·8	68	47·6
Western Reserve	106	60	56·6	9	8·5	37	34·9
Total	249	121	48·6	23	9·2	105	42·2

The unexpected result is that the combined data of the two institutions show that 95 per cent of American Negroes are Gm(a + b +). That this observation is not due to technical errors is shown by the data for American Whites, which agree with those previously reported for European Whites[4]. Unpublished data of Steinberg, Stauffer, Fudenberg and Blumberg indicate that Mongoloid populations are also essentially 100 per cent Gm(a + b +).

There is no reason to suppose that the Gm^a and Gm^b factors are not genetically determined in coloured peoples, but a direct test of this is not possible with the available samples. Assuming genetic determination, the genotypic alternatives are that nearly all coloured individuals are heterozygous for *Gm^a* and *Gm^b* with heterozygosity maintained by a system of balanced lethals, or that coloured populations are homozygous for an allele, *Gm^{ab}*, which determines both Gm^a and Gm^b. The former alternative requires that 50 per cent of all conceptions end in death to maintain heterozygosity and is therefore untenable. We accept the latter alternative.

The phenotypes and their possible genotypes (assuming a Gm^{ab} allele) for the Gm^a and Gm^b factors in Negroes are shown in Table 4. From this table it may be seen that the Gm(a + b −) and the Gm(a − b +) individuals are homozygotes, hence the square roots of their frequencies provide estimates of the frequency of the alleles Gm^a and Gm^b, respectively, in American Negroes. These values (from the combined samples) are $0{\cdot}150 \pm 0{\cdot}020$ for Gm^a, and $0{\cdot}160 \pm 0{\cdot}020$ for Gm^b.

Table 4. Phenotypes and Possible Genotypes for Gm^a and Gm^b in Negroes

Phenotypes	Possible genotypes
Gm(a+ b+)	Gm^{ab}/Gm^{ab} ; Gm^{ab}/Gm^a ; Gm^{ab}/Gm^b ; Gm^a/Gm^b
Gm(a+ b−)	Gm^a/Gm^a
Gm(a− b+)	Gm^b/Gm^b

If we make the reasonable assumptions that the Negro ancestors of the American Negro were homozygous for Gm^{ab}, and that the alleles Gm^a and Gm^b in American Negroes were derived from White ancestors, the sum of their frequencies (0·310) is a measure of the proportion of the genotype of American Negroes which has been derived from these White ancestors. This value agrees with the value derived by Glass and Li[7] (0·306) on the basis of the R^0 allele of the Rh groups and thus reinforces their conclusion that White ancestors have contributed some 30 per cent of the genotype of American Negroes.

Arthur G. Steinberg
Rachel Stauffer
Western Reserve University,
Cleveland, Ohio.
Samuel H. Boyer
Division of Medical Genetics,
Department of Medicine,
Johns Hopkins University School of Medicine.

[1] Grubb, R., and Laurell, A. B., *Acta Path. Microbiol. Scand.*, **39**, 390 (1956).
[2] Harboe, M., *Acta Path. Microbiol. Scand.*, **47**, 191 (1959).
[3] Harboe, M., and Lundevall, J., *Acta Path. Microbiol. Scand.*, **45**, 357 (1959).
[4] Steinberg, A. G., Giles, Brenda Dawn, and Stauffer, Rachel, *Amer. J. Human Genet.*, **12**, 44 (1960).
[5] Steinberg, A. G., Stauffer, Rachel, and Fudenberg, H., *Nature*, **185**, 324 (1960), and unpublished work of Steinberg, A. G., Stauffer, Rachel, Fudenberg, H., and Blumberg, B.
[6] Moullec, J., Fine, J. M., Henry, Cl., and Silverie, Ch., Proc. Seventh Cong. Int. Soc. Blood Transfusion, 881 (1959).
[7] Glass, B., and Li, C. C., *Amer. J. Human Genet.*, **5**, 1 (1953).

Chromosome Number in the Blue Fox (*Alopex lagopus* (L.))

The materials examined consisted of testes from five farm-bred blue foxes (*Alopex lagopus* (L.)) which were killed by electrocution during the breeding season. The testes were immediately removed, teased in distilled water where they remained for about 10 min. and then the pieces were put in either aceto-orcein or 50 per cent acetic acid. From the aceto-orcein coloured preparations, temporary slides were made by the usual squash methods. The preparations fixed in 50 per cent acetic acid were squashed in the same manner and coloured by the Feulgen method[1].

The testicular material under observation contained numerous spermatogonial cells undergoing division. Careful counts of only those metaphase plates which seemed to be intact gave 50 chromosomes as the diploid number (Fig. 1*a*). The diploid complex was remarkable for its comparatively small chromosomes.

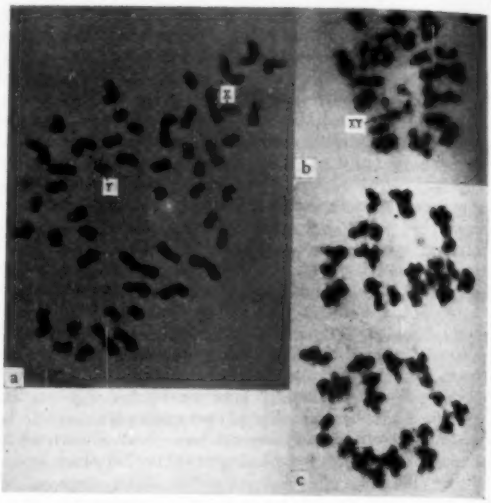


Fig. 1. Chromosomes of the blue fox (*Alopex lagopus*). *a*, Mitotic metaphase with 50 chromosomes. The *X* and *Y* chromosomes are indicated; *b*, first meiotic metaphase with 25 bivalents. The *X*—*Y* complex is indicated; *c*, the second meiotic division. (× *c*. 950)

Because of this the identification of the different chromosomes presented some difficulties. It was found, however, that the diploid complex consisted of 38 meta-centric or sub-metacentric, 11 teleocentric and one dot-like chromosome where the centromere could not be identified. This dot-like chromosome was remarkably smaller than the other ones and apparently has no counterpart. It seems justifiable to consider this to be one of the sex-chromosomes. The other element of the sex-chromosomes seemed to be a rod-shaped chromosome of medium size.

Counts from both the first and the second meiotic division confirmed the number given. The metaphase of the first meiotic division showed 25 bivalents (Fig. 1*b*). Here it was difficult to distinguish the *X*—*Y* complex. It seems that more than one pair of chromosomes have precocious condensation. The second meiotic division was in most cases difficult to count as the chromosomes were small and often lumped together and were diffuse in appearance; but also here 25 chromosomes were found (Fig. 1*c*).

The results obtained in this investigation show that the diploid number of chromosomes in the male blue fox (*Alopex lagopus*) is 50. This is not in agreement with results described earlier. Andes[2] has reported that the number of chromosomes in the blue fox (*Vulpes lagopus*) is approximately between 50 and 60 diploid. He found also 26 tetrads in the first meiotic division. He was, however, unable to distinguish the sex-chromosomes. Wipf and Shackelford[3] agreed with the counts of Andes. They found 52 chromosomes diploid. Neither could these authors find sex-chromosomes on the basis of heteropycnosis, differences in size or other morphological characters.

O. Lande
Flaaten Experimental Laboratory,
Storgt. 51, Oslo.

[1] Matthey, R., *Rev. Suisse de Zool.*, **60**, 225 (1953).
[2] Andes, A. H., *Cyt.*, **9**, 35 (1938–39).
[3] Wipf, L., and Shackelford, R. M., *Proc. U.S. Nat. Acad. Sci.*, **35**, 468 (1949).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 10

INSTITUTION OF CHEMICAL ENGINEERS (at the Royal Institution, Albemarle Street, London, W.1), at 3 p.m.—Symposium on "Surface Effects and Liquid Behaviour".

UNIVERSITY OF LONDON (at the Institute of Education, Malet Street, London, W.C.1), at 5.15 p.m.—Dr. J. M. Tanner (Institute of Child Health): "Physical Development".*

Tuesday, October 11

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. C. W. Allen: "Eclipses of the Sun".*

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (joint meeting with the AGRICULTURE GROUP, at 14 Belgrave Square, London, S.W.1), at 2.45 p.m.—Mr. O. S. Rose, Dr. S. N. Adams, Dr. R. Hull and Dr. R. A. Dunning: "Sugar Beet—Cultivation and Pest Control Measures".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

CEMENT AND CONCRETE ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. L. A. Ashton and Mr. S. C. C. Bate: "Fire Resistance of Pre-stressed Concrete Beams".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. G. Garton: "Time and Insulation" (Chairman's Address).

ROYAL SOCIETY OF MEDICINE, EXPERIMENTAL MEDICINE AND THERAPEUTICS SECTION (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Discussion on "The Kinetics and Control of Erythropoiesis".

UNIVERSITY OF LONDON (in the Main Lecture Theatre, New Physics Building, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 5.30 p.m.—Prof. R. Nevanlinna (Helsinki): "Absolute Analysis".*

ILLUMINATING ENGINEERING SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Dr. W. S. Stiles, F.R.S.: "Lighting and Research" (Presidential Address).

Wednesday, October 12

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Prof. G. H. Lathe: "Biochemical Basis of Liver Function Tests".*

BRITISH COAL UTILIZATION RESEARCH ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. F. J. Dent: "The Hydrogenation of Coal to Methane" (Ninth Coal Science Lecture).

CHALLENGER SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Dr. Jacques Piccard: "With the *Trieste* in the Challenger Deep".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Laboratory Work for the Part III Examination", opened by Dr. P. F. Soper.

BRITISH INSTITUTION OF RADIO ENGINEERS, ELECTRO-ACOUSTICS GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Prof. Colin Cherry: "Electro-Acoustics for Human Listeners" (Inaugural Meeting).

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Royal Institution, 21 Albemarle Street, London, W.1), at 7 p.m.—Prof. V. N. Kondratiev (U.S.S.R. Academy of Sciences): "Energy Exchange in the Interaction of Particles under Electric Discharges" (Second Humphry Davy Lecture).

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (joint meeting with the BIOLOGICAL METHODS GROUP of the SOCIETY FOR ANALYTICAL CHEMISTRY, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Dr. J. H. Hamence, Mr. P. H. Needham, Mr. J. G. Reynolds and Mr. R. Goulden: "Biological Assay of Insecticidal Residues".

WOMEN'S ENGINEERING SOCIETY (at "Hope House", 45 Great Peter Street, London, S.W.1), at 7 p.m.—Mr. J. Rice: "The Use of Microwaves in Telecommunications".

Thursday, October 13

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. H. B. Rycroft: "Proteas of the South Western Cape"; Dr. L. E. Richdale: "The New Zealand Mutton Bird".

UNIVERSITY OF LONDON (at the Royal Veterinary College, Royal College Street, London, N.W.1), at 5 p.m.—Prof. C. W. Emmens (Sydney): "The Biological Assay of Œstrogenic and Anti-Œstrogenic Activity". (Further lecture on October 20.)

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. M. Ferguson: "Developments in Electrical Plant for Industry" (Chairman's Address).

SOCIÉTÉ DES INGENIEURS CIVILS DE FRANCE (joint meeting with the INSTITUTION OF STRUCTURAL ENGINEERS, at 11 Upper Belgrave Street, London, S.W.1), at 6 p.m.—M. Jean Bellier and M. Max Tourasse: "Pre-stressed Concrete Pressure Vessels for Nuclear Reactors at Marcoule".

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. R. A. Raphael: "Recent Studies on Many-Membered Rings" (Tilden Lecture).

RADAR AND ELECTRONICS ASSOCIATION (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Mr. P. S. Carnt: "Colour Television".*

Friday, October 14

ASSOCIATION OF APPLIED BIOLOGISTS (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, South Kensington, London, S.W.7), at 10.45 a.m.—Symposium on "Soil Fauna in Relation to Soil Formation and Fertility".

ANTIQUARIAN HOROLOGICAL SOCIETY (at 35 Northampton Square, London, E.C.1), at 6.30 p.m.—Opening and House-Warming, followed by Mr. Cecil Clutton: "Two Constant-Force Chronometers".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN ORGANIC CHEMISTRY, and an ASSISTANT, Grade A, FOR GENERAL CHEMISTRY at Birkenhead Technical College—The Director of Education, Birkenhead Education Committee, 63 Hamilton Square, Birkenhead (October 12).

METEOROLOGICAL OFFICERS (with a first- or second-class honours degree (or equivalent) in physics or mathematical physics or mathematics or engineering or degree (or equivalent) in meteorology) in the Irish Meteorological Service—The Secretary, Civil Service Commission, 45 Upper O'Connel Street, Dublin (October 14).

ASSISTANT EXPERIMENTAL OFFICER (with at least two subjects at advanced level to include chemistry, zoology or biology, and preferably a knowledge of French and/or German), for work which includes scanning and abstracting scientific literature—The Director, Pest Infestation Laboratory, Agricultural Research Council, London Road, Slough, Bucks (October 15).

ASSISTANT EXPERIMENTAL OFFICERS (2) (with at least two scientific subjects at advanced level, or equivalent) AT THE AGRICULTURAL RESEARCH COUNCIL'S PEST INFESTATION LABORATORY, one for work on insects attacking stored foodstuffs, and the other for work on mycological problems connected with food storage—The Director, Pest Infestation Laboratory, Agricultural Research Council, London Road, Slough, Bucks (October 15).

HEAD OF THE DEPARTMENT OF SCIENCE, Grade III—The Academic Registrar, Hatfield Technical College, Hatfield, Herts (October 15).

HOSPITAL BIOLOGIST (with a first- or second-class honours (B.Sc.) degree in biochemistry or physiology or similar qualifications), for routine and research investigations involving bioassays and chemical procedures—The Deputy Director, Vincent Square Laboratories of Westminster Hospital, 124 Vauxhall Bridge Road, London, S.W.1 (October 15).

LECTURER (with an honours degree in science, preferably in chemistry) FOR WORK ON METHOD IN SCIENCE, to help undergraduate students of science and engineering to clarify their attitudes to science through using discussion and other methods of teaching which have already been developed in the college—The Registrar, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3 (October 15).

LECTURERS (2) (with an honours degree in chemistry, with teaching and research or industrial experience) IN THE DEPARTMENT OF CHEMISTRY, one for Organic and one for Inorganic Chemistry—The Principal, Whitehaven College of Further Education, Whitehaven, Cumberland (October 15).

PRINCIPAL OF THE INSTITUTE OF AGRICULTURE, Moulton—Chief Education Officer, County Education Offices, Northampton (October 15).

READER IN MATHEMATICS—Prof. Titchmarsh, Mathematical Institute, The University, Oxford (October 15).

SENIOR LECTURER (with high academic qualifications and preferably industrial and research experience) IN PHYSICAL CHEMISTRY—The Registrar, Lanchester College of Technology, Priory Street, Coventry (October 15).

LECTURER IN PHYSICS AND/OR CHEMISTRY—The Principal, Bede College, Durham (October 22).

LECTURER IN STATISTICS—The Registrar, University College of North Staffordshire, Keele, Staffs (October 24).

ASSISTANT LECTURER (with special qualifications in genetics, cytology or taxonomy) IN BOTANY—The Secretary, The Queen's University, Belfast (October 31).

LECTURER/ASSISTANT LECTURER (preferably with a good honours degree in either agricultural science or veterinary science, suitable research and teaching experience, and previous practical experience in animal husbandry, including the breeding, feeding and management of farm livestock, preferably under tropical conditions) IN ANIMAL SCIENCE at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Malaya and London, October 31).

PRINCIPAL OF ABERDEEN COLLEGE OF EDUCATION—The Principal, The College of Education, St. Andrew Street, Aberdeen (October 31).

CHAIR OF ANATOMY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 5).

LECTURER IN ORGANIC CHEMISTRY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 7).

RESEARCH FELLOWS (with interests in the following fields: (*a*) geomorphology, (*b*) biogeography (including plant ecology), or (*c*) social or economic geography) IN THE DEPARTMENT OF GEOGRAPHY, Research School of Pacific Studies, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 7).

CHAIR IN PLANT SCIENCE—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand (November 30).

DEMONSTRATORS (preferably with an honours degree) IN INORGANIC AND PHYSICAL CHEMISTRY at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, November 30).

LECTURER IN METALLURGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, November 30).

LOGAN CAMPBELL CHAIR IN FOOD TECHNOLOGY—The Registrar, Massey Agricultural College, University of New Zealand, Palmerston North, New Zealand (November 30).

SENIOR LECTURER or LECTURER IN MINING at the University of Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, November 30).

SCIENTIFIC OFFICER (honours graduate in zoology), for work on plant parasitic nematodes—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (November 30).

WALTER CLARKE BUCHANAN CHAIR IN AGRICULTURAL ECONOMICS AND FARM MANAGEMENT—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand (November 30).

LECTURERS or ASSISTANT LECTURERS (2) (with at least a good honours degree in zoology or equivalent qualification, experience in teaching and research, and preferably with a special knowledge of entomology or arthropod zoology in general for one of the two posts) IN THE DEPARTMENT OF ZOOLOGY at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Kuala Lumpur and London, December 1).

ASSISTANT, Grade B (graduate, preferably with teaching and/or research and/or industrial experience, capable of taking classes to B.Sc. (General) degree and H.N.C. level, and preferably a member of the Royal Institute of Chemistry), IN CHEMISTRY—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford, Essex.

ASSISTANT LECTURER, Grade B (with an honours degree in zoology with subsidiary botany or a general degree in botany and zoology, and prepared to teach zoology to B.Sc. General and botany and zoology to G.C.E. advanced level standard) IN BIOLOGY—The Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent.

BIOCHEMIST, Basic grade (graduate in chemistry or Associate or Graduate Member of the Royal Institute of Chemistry), IN THE DEPARTMENT OF PATHOLOGY—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

BIOCHEMIST (Senior grade), to take charge of the East Riding Group Laboratory—The Hospital Secretary, Westwood Hospital, Beverley, East Yorkshire.

BIOLOGIST or BIOCHEMIST, to work in the United Birmingham Hospitals, Department of Clinical Endocrinology, on the immunological properties of pituitary hormones; and a BIOCHEMIST (Basic grade), to work on the determination of steroid hormones—The Director, Department of Clinical Endocrinology, Birmingham and Midland Hospital for Women, Showell Green Lane, Birmingham 11.

CHEMIST/ASSAYER (man or woman, preferably under 40, with a good honours degree in chemistry or equivalent professional qualification, and preferably with experience in inorganic analytical chemistry and a good knowledge of instrumental methods and/or electronics) IN THE MINES AND GEOLOGY DEPARTMENT, Government of Kenya, for duties which will include assaying and quantitative analysis of rocks, minerals and ores, and advising on metallurgical and chemical treatment problems connected with mineral extractions—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.99/7/07/T.

GRADUATE ASSISTANT IN THE ENDOCRINE UNIT, to take part in biological, immunological and chemical techniques—The Chemical Pathologist, Hospital for Sick Children, Great Ormond Street, London, W.C.1.

GRADUATES IN CHEMISTRY OR METALLURGY, for fundamental studies of electro-deposition of metals and alloys—The Head of the Department of Metallurgy, Battersea College of Technology, London, S.W.11.

HEAD (preferably with a knowledge of the agricultural industry) OF THE DEPARTMENT CONCERNED WITH THE BIOCHEMISTRY OF ANIMAL NUTRITION—The Secretary, Rowett Research Institute, Bucksburn, Aberdeen.

LECTURER (with a good honours degree, and teaching experience, able to teach statistics to B.Sc. General Degree level, and preferably the ability to teach numerical analysis) TO TEACH PURE AND APPLIED MATHEMATICS AND STATISTICS to G.C.E. Advanced level and B.Sc. General Degree—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

LECTURER (with an honours degree in electrical engineering and industrial experience) IN ELECTRICAL ENGINEERING with interests in Telecommunications—Northampton College of Advanced Technology, St. John Street, London, E.C.1.

RESEARCH WORKER (BIOCHEMIST or CHEMICAL PHARMACOLOGIST, with a Ph.D. or equivalent experience), to investigate the biochemical actions of drugs currently used in the treatment of mental illness—The Director of Clinical Research, Crichton Royal, Dumfries.

SENIOR LECTURERS or LECTURERS (with a first- or second-class honours degree, a thorough grounding in electrical engineering, experience in electrical power and machines, and/or electrical theory and measurements) IN ELECTRICAL ENGINEERING, at the Royal Military College of Science, Shrivenham, Berks—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.627/0A.

SENIOR TECHNICIAN (fully conversant with general workshop practice and with practical electrical experience) IN THE DEPARTMENT OF X-RAY TECHNOLOGY, for duties which will include routine maintenance of X-ray apparatus—The Administrative Assistant, Churchill Hospital, Oxford.

SOIL CHEMIST (with a good honours degree in chemistry or agricultural science with postgraduate training or experience in soil science) in Sarawak, to take charge of the Soils Laboratory and to undertake soil and plant analyses—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/24/08/T.

TECHNICAL ASSISTANT (preferably with some experience of standard histological techniques), for interesting and varied work in the Histology Department—The Administrative Officer, Nutritional Research Unit, Huntingdon.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Steel Castings Research Association. Seventh Annual Report, 1960. Pp. ii+34. (Sheffield: British Steel Castings Research Association, 1960.) [197

University of Birmingham: Institute of Education. Education in an Age of Technology: a Report on the Fifth Summer School held at Worcester 1959. Pp. 151. (Birmingham: University of Birmingham, Institute of Education, 1960.) [197

World Power Conference. Annual Report, 1959. Pp. 18. (London: World Power Conference, 1960.) [197

Notes and Records of the Royal Society of London, Vol. 15. (Tercentenary Number). Pp. ix+275+29 plates. (London: The Royal Society, 1960.) 30*s*. [197

Institute of Physics. Fortieth Annual Report of the Board of the Institute of Physics for the year 1959. Pp. 19. (London: Institute of Physics, 1960.) [197

General Register Office. The Registrar General's quarterly return for England and Wales. No. 445 (1st Quarter 1960): Births, Deaths and Marriages; Infectious Diseases; Weather; Population Estimates, quarter ended 31st March 1960. Pp. 28. (London: H.M. Stationery Office, 1960.) 2*s*. net. [197

Report by the Hydrographer of the Navy for 1959. Pp. 30+4 plates. (London: Admiralty, 1960.) [197

Other Countries

Annals of the New York Academy of Sciences. Vol. 83, Article 1: Molecular Organization in Solid High Polymers. By F. A. Bettelheim and 8 other authors. Pp. 1–76. 2.50 dollars. Vol. 83, Article 2: The Vagina. By Warren R. Lang and 43 other authors. Pp. 77–358. 4 dollars. Vol. 86, Article 1: Nonnarcotic Drugs for the Relief of Pain and their Mechanism of Action. By F. M. Berger and 50 other authors. Pp. 1–310. 3.50 dollars. (New York: New York Academy of Sciences, 1959 and 1960.) [197

Organization for European Economic Co-operation: European Nuclear Energy Agency. The Industrial Challenge of Energy, 3: Stresa Conference. Part 4: The Market for Nuclear Equipment and Instrumentation. Pp. 272. (Paris: Organization for European Economic Co-operation, European Nuclear Energy Agency; London: H.M. Stationery Office, 1960.) 12 NF.; 18*s*. 6*d*.; 3 dollars; 12 Swiss francs; 10.20 D.M. [197

East Africa High Commission. East African Marine Fisheries Research Organization Annual Report, 1959. Pp. ii+18. (Nairobi: Government Printer, 1960.) Sh. 4. [197

XII Jornada Clinica de Verano, 1959. (Organizada por la Fundacion Lucas Sierra de Vina del Mar, y Sociedad Medica de Valparaiso.) Pp. xvi+379. (Vina del Mar, Chile: Fundacion Lucas Sierra, 1959.) [197

1st International Symposium on Fleming's Lysozyme, Milano, April 3rd, 4th, 5th, 1959—Abstracts of Relations and Communications. Pp. 151. (Milano: Museo della Scienza e della Tecnica, 1950.) [197

Smithsonian Institution: United States National Museum. Bulletin 216, Part 2: Ichneumon-Flies of America North of Mexico. 2: Subfamilies Ephialtinae, Xoridinae, Acaenitinae. By Henry and Marjorie Townes. Pp. vii+676 (378 figures). (Washington, D.C.: Government Printing Office, 1960.) 2.50 dollars. [197

United States Department of Agriculture. Index-Catalogue of Medical and Veterinary Zoology. Supplement 9, Authors: A–Z. By Mildred A. Doss, Judith M. Humphrey and Dorothy B. Segal. Pp. i+322. 1.25 dollars. Index-Catalogue of Medical and Veterinary Zoology. Supplement 10, Authors: A to Z. By Mildred A. Doss, Judith M. Humphrey and Dorothy B. Segal. Pp. i+357. 1.25 dollars. (Washington, D.C.: Government Printing Office, 1959 and 1960.) [197

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office